EPIDEMIOLOGY OF
HEMOLYTIC STREPTOCOCCUS

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During World War II in the United States Navy

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DEDICATION

This volume is dedicated with deep respect to Vice Admiral Ross T McIntire (MC) USN, to Captain T. J. Carter (MC) USN, to the one hundred and thirty Medical Officers and the three hundred and ninety-seven enlisted personnel of the Naval Reserve, whose combined vision, courage, industry and loyalty during World War II created twenty-two Navy Epidemiology Units within the continental limits of the United States.

CONTENTS

mide resistance of hemolytic streptococcus in vitro (4). Fortuitously, this roughly quantitative technique seems to make possible the differentiation of certain strains of hemolytic streptococcus within types 19, 17 and 3, which were most prevalent during World War II in The U. S. Navy.

Prior to World War II the mildness of streptococcal infections had tended to lull general interest in this bacterium, in spite of its well known cyclic trends of pathogenicity. Furthermore, the recent introduction of

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14	MIAMI, FLA	80	SAN DIEGO CALIF
19	MEMPHIS, TENN	81	LONG BEACH, CALIF
20	CAMP LEJEUNE, N.C	82	SHOEMAKER, CALIF
21	CORPUS CHRISTI, TEX	"	TREASURE ISLAND, CALIF
22	FARRAGUT IDAHO	"	OAKLAND, CALIF
24	NORFOLK VA	89	CHICAGO ILL
42	CHELSEA, MASS. DAVISVILLE, RI	100	BETHESDA, MD
43	NORMAN, OKLA	120	NEW YORK, NY
NO. 44	CHARLSTON, S C	*	SPECIAL UNIT, SEATTLE WASH
" 46	NEW ORLEANS, LA.		
" 47	PHILADELPHIA, PA.		
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FIG 1 The Locations of Laboratory Teams of Naval Medical Officers in World War II

chemotherapeutic agents had brought a false sense of security, even though hemolytic streptococci continued to cause high morbidity among the civilian population That the full significance of this microorganism had not been appreciated became apparent in three ways during World War II· First came a tremendous loss in man days owing to streptococcal infections of the upper respiratory tract. Second, almost every outbreak of these infections was followed by such a high incidence of rheumatic fever that by 1944 the importance of this disease exceeded that of malaria

Third, by 1945 the three most prevalent types of Group A hemolytic streptococcus were found to include strains which had the capacity to resist the action of sulfonamides, both in vivo and in vitro.

These experiences initiated a renaissance of interest in hemolytic streptococcus As a result, more extensive and more intensive field work was done on streptococcal infections than had been possible previously. The regulations of life in the Navy facilitated the making of controlled observations on the spread of hemolytic streptococcus, which had not previously been possible in populations with unrestricted travel The collected observations made during the war years are the basis of the present report.

This report might readily be limited to an historical description or to a series of statistical summaries, however, this limitation would defeat its purpose. Instead it has seemed profitable, even though perhaps not discreet, to attempt to indicate the interrelation of the observed diverse contemporary clinical phenomena and to reconstruct an ordered view of their sequential relations On the success of such attempts will depend comprehension of the natural history of *Streptococcus hemolyticus* and subsequently the development of methods for the control of this bacterium However, control requires more than making and interpreting observations in the field The control of streptococcal infections requires knowledge of those physiologic principles and of the biochemical organization within the bacterial cell which determine its adaptability to the human host

The epidemiologist finds that exceptional intuitive powers are required to grasp interrelationships as they occur "in the field" and soon his serious intent drives him to seek a tracing from phenomena back to first principles But, in such an attempt, he is often thwarted, first by his own lack of discipline in organizing research in the laboratory and second, by the lack of methods for collecting the pertinent facts on critical problems. The epidemiologist "in the field" does observe, record, check, analyze, evaluate, reevaluate, interpret and emerge with a problem, only to learn in many instances that the solution of his problem must await advances in the fundamental disciplines For the epidemiologist, the horizons are broad, he finds much surface gold, but he is rarely prepared to dig deep and strike the underlying vein. In contrast, his scientific colleagues working in the laboratory may not be aware of the surface phenomena and the all-important underlying veins It is essential that the problems of the man in the field be called to the attention of the man in the laboratory before one can hope for the development of methods needed for the control of hemolytic streptococcus. At present, no problem in epidemiology presents a greater challenge than the control of the ubiquitous spread of hemolytic streptococcus.

The authors were intimately associated with the findings to be reported in this monograph However, these observations represent the work of

which are not included in the scarlet fever statistics. Likewise, there were more cases of rheumatic fever than were recorded under this diagnosis. Altogether 21,209 illnesses were classified as rheumatic fever (Table 3).

TABLE 1

The Occurrence of Valvular Heart Diseases

Navy and Marine Corps, 1942-1945

Diagnosis and year	Admissions						Sick Days
	REM	EPTE	A	ACD	AD	RA	
Aortic and Mitral Insufficiency							
Total		524	215	314	72	72	68,101
1942	1	79	13	2	—	1	3,476
1943	24	219	34	99	—	16	16,330
1944	31	151	88	69	—	26	23,720
1945	89	75	80	144	72	29	24,575
Mitral Stenosis							
Total		922	364	213	85	149	83,620
1942	10	154	24	19	—	4	7,640
1943	49	387	57	48	—	14	18,975
1944	51	294	144	68	—	59	32,814
1945	102	87	139	78	85	72	24,191
Mitral Insufficiency							
Total		1,788	746	1,297	130	365	210,691
1942	29	321	22	141	—	7	20,087
1943	53	597	137	413	—	39	49,848
1944	153	585	276	181	—	115	65,906
1945	211	285	311	562	130	204	74,850

Source Navmed-Fr-card, "Individual Statistical Report of Patient"

Legend for abbreviations

REM—Remainder
EPTE—Existed prior to enlistment
A—New Admissions
ACD—Admitted Contributory Disability
AD—Additional Diagnosis
RA—Readmissions

However, in the Navy, only one diagnosis is assigned at one time to each illness. At least 8,089 patients with rheumatic fever who developed cardiac stigmata were classified under valvular heart disease. These data are shown in Table 1. In addition, there were 14,150 cases

classified as acute arthritis[1] These data are shown in Table 2. Most of the patients with these diagnoses probably had rheumatic fever but were given on discharge the diagnosis which was considered most significant. In scarlet fever, the diagnosis was usually made on the station where the infection was contracted. However, this was not true for rheumatic fever which commonly developed two weeks or more after infection. For example, a follow-up study was made of a sample of 500 men of a group of 1,598 who contracted scarlet fever in the winter of 1945 at the San Diego Naval Training Center This study showed that 106 of these 500 men developed rheumatic fever. However, in most instances this disease did not become manifest until their recruit training was completed. For this

TABLE 2

The Occurrence of Acute Arthritis

Navy and Marine Corps, 1943–1945

Year	Admissions						Sick Days
	Rem	EPTE	A	ACD	AD	RA	
Total		639	11,340	227	189	948	431,818
1942	32	28	975	19	—	77	30,513
1943	98	142	2,983	44	—	229	94,693
1944	322	326	4,031	70	—	346	156,946
1945	355	143	3,351	94	189	296	149,666

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[1] Chronic arthritis, listed in Navy nomenclature as distinct from arthritis deformans, became a disease of great importance during the four war years Between January 1942 and 1946 there were 25,478 cases The rate per 100,000 rose progressively each year from 63.2 in 1938 to over 300 in 1944 and the first eight months of 1945 As a cause of man days lost and as a cause for invaliding from service, it rose from insignificance to seventh place and fifth place successively Less than half of these patients had any history of arthritis prior to entering the Navy [illegible] under 20 and the highest in the age group of 45–49 The rates per 100,000 for these two groups were 47.5 and 2,263 3 respectively The morbidity rates per 100,000 for enlisted men was 268 9 and for officers 146 1

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fever understate the extent of the rheumatic process in the U. S. Navy.

Streptococcal respiratory tract infections in young adults of the United States are accompanied by scarlet fever in not more than 5% of cases and are followed by rheumatic fever in not more than 2% of cases. If one estimates all of the streptococcal infections in the Navy by multiplying the cases of scarlet fever by twenty or the number of cases of rheumatic fever by 50 (Naval personnel were screened on enlistment to rule out members with a rheumatic history or rheumatic stigmata) the conclusion

TABLE 3

Scarlet Fever and Rheumatic Fever (Incidence and Rates, by Location)

Navy and Marine Corps, 1942–1945

Computed on Annual Basis per 100,000

Year	Total		Continental Naval Districts		Non Continental Areas		Ships	
	Incidence	Rate	Incidence	Rate	Incidence	Rate	Incidence	Rate
				Scarlet Fever				
Total	59,458	596 57	56,917	1,089 61	888	45 52	1,653	59 20
1942	1,348	161 51	1,180	229 24	103	93 53	65	30 99
1943	14,040	665 91	13,588	1,053 62	177	53 95	275	56.05
1944	16,953	506 09	15,978	975 74	274	40 51	701	67 68
1945	27,117	738 11	26,171	1,468 88	334	39.95	612	57 94
				Rheumatic Fever				
Total	21,209	212 80	17,696	338 77	1,191	61 06	2,322	83 15
1942	868	104 00	633	122 97	73	66 29	162	77 60
1943	5,807	275 42	5,095	395 07	288	87 78	424	86 42
1944	7,667	228 79	6,251	381 73	505	74 65	911	87 95
1945	6,867	186 92	5,717	320 88	325	38 88	825	78 11

is reached that during the four war years at least 1,000,000 personnel contracted a streptococcal infection in the U S Navy. The relative incidence of these diseases as they occurred in the Navy is summarized in Table 3. This table prepared from statistical reports of The Bureau of Medicine and Surgery shows the morbidity rates per 100,000 for scarlet fever and rheumatic fever in the continental districts were several times in excess of those in non-continental areas and aboard ships. The rates aboard ships exceeded those in non-continental areas However, the rates aboard ships reflected to a degree infections contracted ashore within the continental

limits The highest rates within the continental limits occurred each year in recruit training camps. These camps were located in states where the civilian scarlet fever rates per 100,000 remained at the relatively low levels of 104 in 1943, of 163 in 1944, and 125 in 1945.

SIGNIFICANCE OF THE NAVY'S STREPTOCOCCAL PROBLEM DURING WORLD WAR II TO THE ECONOMY OF THE UNITED STATES

Streptococcal diseases were costly to the Navy in the loss of man days Excluding nearly one million man days lost through heart disease and polyarthritis, rheumatic fever ranked third in the loss of man days to disease. Each sick man required the attendance of two medical personnel.

TABLE 4

Average Number of Days Spent on the Sick List in 1942–1943 for Diseases Commonly Initiated by Streptococcus Hemolyticus

Diagnosis	Man-Days Loss
Catarrhal fever acute	4 9
Rhinitis, acute	5 2
Pharyngitis, acute	5 5
Tonsillitis, acute	5 7
Laryngitis, acute	6 2
Tracheitis, acute	6 8
Bronchitis, acute	8 5
Tracheo-bronchitis, acute	10 5
Otitis media, acute	10 8
Sinusitis, acute	15 8
Scarlet fever	21 9
Pneumonia, bronchial	26 4
Mastoiditis, acute	60 6
Rheumatic fever	92 1
Empyema (estimated)	100

In many instances, he was required to repeat his training The time that each man spent on the Sick List was determined by the character of his disease In 1942 and 1943, days lost varied from 4 9 in the mild upper respiratory tract infections, classified in many instances as "catarrhal fever," to an estimated 100 for primary streptococcal pneumonia[3] with empyema The average time lost in various streptococcal diseases is shown in Table 4.

The Training Center at Farragut, reported during its first year that with an average strength of 43,000 there were at least 50,000 minor streptococcal infections of the naso-pharynx, 4,973 cases of scarlet fever, and 1,375 cases

[3] This diagnosis was not in the Navy classification and the time lost is estimated from suppurative pulmonary infections due to respiratory tract pathogens

TABLE 5

Rheumatic Fever and Scarlet Fever New Admissions and Rates for Large Naval Activities Navy and Marine Corps, 1943–1945

Location	Average Strength			Rheumatic Fever						Scarlet Fever					
	1943	1944	1945	1943		1944		1945		1943		1944		1945	
				Adm	Rate	Adm	Rate	Adm	Rate	Adm	Rate	Adm	Rate	Adm.	Rate
New England															
NCTC, Davisville	12,005	14,181	16,703	4	0.3	7	0.5	60	3.6	57	4.7	8	0.6	188	11.2
NTS, Newport	21,133	17,952	15,413	68	3.2	41	2.3		1.4	216	11.0	184	10.2	118	7.0
NAS, Quonset	9,259	14,267	13,363	16	1.7	15	1.0	4	0.3	26	2.8	8	0.6	21	1.6
New York															
Armed Guard Center, Brooklyn	33,792	53,936	31,926	6	0.2	—	0	3	0.1	17	0.5	120	2.2	15	0.5
NTC, Sampson	29,982	40,066	27,662	37	1.2	21	0.5	64	2.3	605	20.2	198	4.8	1908	63.0
South Atlantic Seaboard															
NTS, Bainbridge	22,254	31,818	27,671	40	1.8	107	3.4	65	2.3	344	15.4	335	10.5	1549	56.0
Camp Lejeune	24,720	34,002	26,020	5	0.2	16	0.5	9	0.3	42	1.7	40	1.2	11	0.4
NAC, Hampton Roads	18,370	27,312	27,471	8	0.4	5	0.2	3	0.1	27	1.5	12	0.4	13	0.5
NTS, Norfolk	11,936	15,456	10,986	13	1.1	37	2.4	12	1.1	33	2.8	119	7.7	84	7.6
NCTC, Williamsburg	40,461	36,939	22,629	2	0.0	—	0	17	0.8	91	2.2	50	1.4	175	7.7
NAS, Jacksonville	12,838	13,627	13,869	—	0	—	0	1	0.1	1	0.1	—	0	3	0.2
MarBaks, Parris Is	16,922	14,874	16,167	3	0.2	3	0.2	16	1.0	—	0	8	0.5	6	0.4
South															
NATC, Pensacola	20,604	27,801	25,093	1	0.0	6	0.2	1	0.0	4	0.2	6	0.2	2	0.1
NATTC, Memphis	12,239	14,408	9,215	2	0.2	94	6.5	9	1.0	354	28.9	306	21.2	65	7.0
NATTC, Norman	13,301	16,017	11,336	20	1.5	24	1.5	13	1.1	215	16.2	171	10.7	706	62.4
NATC, Corpus Christi	21,746	27,894	25,981	—	0	5	0.2	5	0.2	2	0.1	2	0.1	4	0.2
Chicago Schools															
NATTC, Navy Pier	10,192	6,010	5,744	192	18.8	128	21.3	4	0.7	631	61.9	177	29.4	194	33.8
NATTC, Anthony Ave.	85	2,700	2,658	—	0	6	2.2	—	0	—	0	3	1.1	2	0.8
Pre-Radio School, Wright[1]	886	1,168	1,132	5	5.6	18	15.4	16	14.1	48	54.2	144	123.3	237	209.4
Pre-Radio School, Manley[2]		1,378	1,306			2	1.4	5	3.8			59	42.9	182	139.4
Pre-Radio School, Herzl[3]		757	652			1	1.3	4	6.1			15	19.8	118	181.0

Illinois[1]															
NTC, Great Lakes	72,187	79,377	57,317	478	0.6	174	2.2	185	3.2	658	9.1	1579	19.9	6789	118.4
California															
San Diego															
Navy Repair Base	18,544	21,716	19,120	13	0.7	58	2.7	19	1.0	67	3.6	136	6.3	15	0.8
Navy Tra & Replacement Camp															
Elliott	13,226	9,806	12,334	10	0.8	31	3.5	11	0.9	14	1.0	31	3.2	31	2.5
NTC, San Diego	27,172	28,765	30,125	54	2.0	20	0.7	43	1.4	142	5.2	415	14.4	1598	53.0
NAS	5,550	16,305	20,445	1	0.2	13	0.8	4	0.2	10	1.8	14	0.8	3	0.1
San Francisco															
NTC, Treasure Is	24,742	55,759	61,059	6	0.2	42	0.8	35	0.6	24	1.0	52	0.9	73	1.2
Receiving Ship[4]	13,782	16,692	—	12	0.9	11	0.6	—		24	1.7	16	1.0	—	
Idaho															
NTC, Farragut	42,172	43,025	7,100	822	19.5	1006	25.0	166	23.4	4546	107.8	4862	113.0	181	25.5
Washington															
N Y, Puget Sound	10,463	13,378	12,132	—	0	—	0	2	0.2	15	1.4	67	5.0	77	6.3

Source Communicable Disease Reports (Jan 1943–Mar 1945)
NavMed—582, Monthly Morbidity Reports (Jun -Dec 1945).

Notes Rates are computed on an annual basis per 1,000 average strength

[1] Commissioned June 19, 1943

[2] Commissioned January 23, 1944

[3] Commissioned April 14, 1944

[4] Combined with NTC, Treasure Island, July 4, 1944

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Chicago Schools															
NATTC, Navy Pier	10,192	6,019	5,744	192	18.8	128	21.3	4	0.7	631	61.9	177	29.4	191	33.8
NATTC, Anthony Ave	85	2,700	2,058	—	0	6	2.2	—	0	—	0	3	1.1	2	0.8
Pre-Radio School, Wright[1]	886	1,168	1,132	5	5.6	18	15.4	16	14.1	48	54.2	144	123.3	237	209.4
Pre-Radio School, Manley[1]		1,376	1,306			2	1.4	5	3.8			59	42.9	182	139.4
Pre-Radio School, Herzl[1]		757	652			1	1.3	4	6.1			15	19.8	118	181.0

with rheumatic fever, heart disease and suppurative infections) will amount to hundreds of millions of dollars.

THE INFLUENCE OF GEOGRAPHICAL LOCATION ON THE MAGNITUDE OF THE STREPTOCOCCAL PROBLEM

Table 5 shows the morbidity rates for scarlet fever and rheumatic fever at large Naval activities during the last three years of World War II when rheumatic fever as well as scarlet fever was reported. The seasonal distribution of respiratory tract diseases is shown in Figure 1 and of four streptococcal diseases in Figures 2a and 2b.

In New England high morbidity rates for scarlet fever and rheumatic fever were reported from the Newport Training Center. In New York

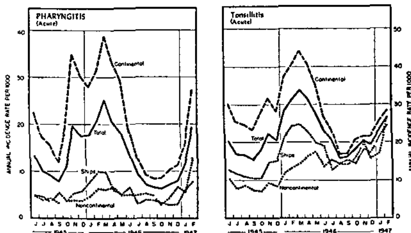


FIG 2a The Seasonal Distribution of Acute Pharyngitis and Acute Tonsillitis From (Statistics of Navy Medicine)

State high morbidity rates for scarlet fever and rheumatic fever were reported from the Sampson Naval Training Center. On the south Atlantic seaboard high morbidity rates for scarlet fever and rheumatic fever were reported from Bainbridge Naval Training Center. In the South, high morbidity rates for scarlet fever and rheumatic fever were reported from the Naval Air Technical Training Centers at Memphis and Norman. In the Southwest high morbidity rates for scarlet fever were reported from the San Diego Naval Training Center in 1944 and 1945 In the Northwest high morbidity rates for scarlet fever and rheumatic fever were reported from the Farragut Naval Training Center. In the Midwest high morbidity rates for scarlet fever and rheumatic fever were reported from the Great Lakes Naval Training Center and the Chicago pre-radio training schools

classified as rheumatic fever or rheumatic heart disease. The estimated man days lost to minor streptococcal infections of the naso-pharynx was 285,000, to rheumatic fever 126,637, and to scarlet fever 108,908. The loss in man days from these three manifestations of streptococcal infections in the first year at Farragut was 520,645. The care of these patients required 1,011,290 days of the medical staff. Altogether over a million and a half days were consumed at a cost in salaries estimated at about $5,000,000 and a potential cost in pensions for 1,375 cases of rheumatic fever of ($10,000 per case) $13,750,000. These estimates are for one station, for only

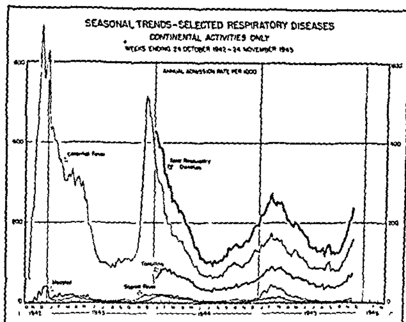


Fig 1 The Seasonal Distribution of Respiratory Tract Infections at Naval Activities in the United States (From Statistics of Navy Medicine)

one year, and for *only three streptococcal manifestations* which *do not* include the suppurative diseases. Furthermore, these estimates do not indicate the cost of convalescence. For example, two large convalescent hospitals were built by the Navy to care for rheumatic fever patients. These were expensive to construct and maintain. There can be little doubt that the total cost to the United States for a million Navy streptococcal infections throughout the war years, including more than 50,000 cases of scarlet fever and over 40,000 cases of rheumatic fever, rheumatic heart disease and acute arthritis (with pension possibilities for patients

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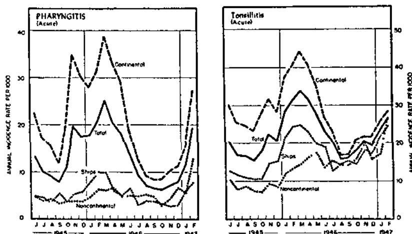


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at *Herzl*, *Manley*, *Wright*, and *Navy Pier*. These observations show that high morbidity rates for these diseases occurred at Recruit Training Centers irrespective of location. The rates at centers located in the North were higher than those located in the South. The highest incidence of streptococcal diseases among recruits occurred at the Navy's northernmost training center in Farragut, Idaho. In northern states the "streptococcal season" began months earlier and ended months later than in southern states. Scarlet fever occurred in high incidence throughout the summer months only at the Farragut Training Center. This unusual seasonal trend is shown in Figure 3.

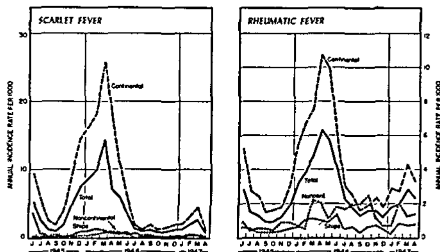


FIG 2b The Seasonal Distribution of Scarlet Fever and Rheumatic Fever. (From Statistics of Navy Medicine)

THE INFLUENCE OF FACTORS OTHER THAN LOCATION ON THE MAGNITUDE OF THE STREPTOCOCCAL PROBLEM

Conditions inherent in the training of recruits appeared primarily responsible for the Navy's streptococcal problem during World War II. The cessation of recruit training at Newport in 1944, at Farragut early in 1945, and at Sampson late in 1945 was followed in each instance by a sharp fall in the scarlet fever morbidity rate At this time, morbidity rates rose at those centers which continued recruit training

Another factor that appeared to predispose to high morbidity rates was the transfer of members of the Outgoing Unit of a training center to distant Naval activities This dissemination of infections by drafts of transfers was by no means limited to hemolytic streptococcus A severe outbreak of meningococcus infection in Davisville, Rhode Island followed the arrival of construction battalion men from Williamsburg, Virginia

(11). Diphtheria, mumps, measles and other communicable diseases were spread by transfers from one station to another. However, the magnitude of the streptococcal problem transcended other problems in contagion and seemed to be determined to a large degree by the transfer of communicable strains of hemolytic streptococcus which were highly pathogenic to man. Naval stations that received no transfers from training camps escaped severe streptococcal outbreaks irrespective of location and season. For example, at Quonset, Rhode Island, where young aviators were barracked

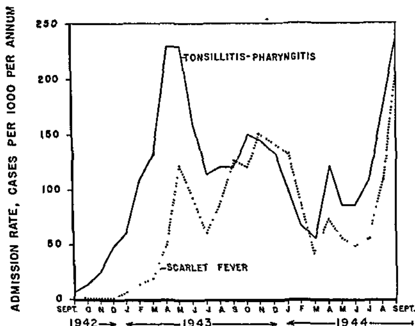


FIG 3 The Unusual Seasonal Trend of Streptococcal Infections Recorded at Farragut, Idaho

in quarters similar to those at Davisville, the average three year morbidity rate for scarlet fever was 1 66. Ten miles away at Davisville, Rhode Island, where an older group of men were trained for construction battalions, the average rate was 5 4 In 1945 it was 11 2 Quonset received its men from civilian life. At Davisville, the incoming drafts included men from training centers where streptococcal infections were epidemic. Sporadic small outbreaks of streptococcal infections occurred at the Quonset Air station among persons who, in most instances, had come directly from civilian life However, in the absence of transfers from recruit

training camps there was no epidemic at Quonset. This was true also at the Armed Guard Center, Brooklyn, New York. There, although the environmental conditions appeared predisposing to the spread of contagion, the average scarlet fever rate was only 1.1. Other Naval activities that received no transfers from recruit training also escaped streptococcal outbreaks. Scarlet fever was no problem at any of the Camps of the U. S. Marine Corps. For example, the average morbidity rate at Camp Lejeune in North Carolina was 1.1 and at Parris Island, South Carolina was 0.3. Likewise, scarlet fever was no problem at the Air Stations. For example,

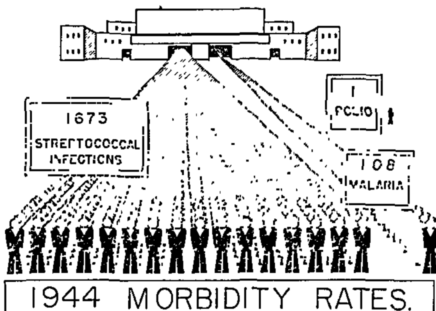


Fig 4 A Comparison of Morbidity Rates for Streptococcal Infections, Malaria and Poliomyelitis

the average morbidity rate at Jacksonville, Florida was 0 1, at Pensacola, Florida 0 2 and at Corpus Christi, Texas, 0.1. These three air stations were located in the deep South, where environmental conditions may have been unfavorable to the spread of hemolytic streptococcus, however, the northern air station at Quonset, Rhode Island had little scarlet fever when streptococcal outbreaks occurred a few miles away at Newport and Davisville Likewise, when scarlet fever epidemics occurred in training centers of the South at Memphis, Tennessee and San Diego, California, the air stations situated less than ten miles away escaped this disease.

The highest scarlet fever rates among seasoned personnel occurred in

the pre-radio schools of Chicago The average annual rates per 1000 were 129.6 at Wright, 91.1 at Manley, 181.0 at Herzl which was in operation only during the last year of the war. These three schools had a turnover of personnel every month. All trainees came from the Outgoing Units of Naval Training Centers In contrast, a comparable school at Anthony Avenue, Chicago had the low scarlet fever morbidity rate of 0.6 in 1944–45. The personnel of this school did not come from recruit training camps. At Treasure Island where seasoned men were trained, scarlet fever morbidity rates were low except in the Radio Materiel School This school received men from the radio school at Del Monte which in turn received transfers from the Chicago pre-radio schools: Wright, Manley and Herzl

SUMMARY

Streptococcal infections during World War II caused a great loss in man days among Naval personnel and a great expense to the American public. The incidence of these infections was highest in the recruit training camps situated in northern states The relative significance of streptococcal infections, malaria and poliomyelitis is shown in Figure 4.

CHAPTER III

THE MECHANISMS OF SPREAD OF STREPTOCOCCUS HEMOLYTICUS WITHIN A NAVAL TRAINING STATION

Air-borne epidemics of streptococcal infections of the upper respiratory tract are ordinarily gradual in onset even though they periodically cause pandemics in civilian populations of American cities. This was not true, however, of infections presumably air-borne at Naval Training Activities. Irrespective of size and location, streptococcal outbreaks had precipitous onsets and within a few days or few weeks streptococcal infections became widely disseminated among what appeared to be well segregated camps of Naval Training Centers. A satisfactory explanation for the rapid spread of hemolytic streptococcus at Naval Activities has not been forthcoming. The present report deals with some of the determining factors at seven large training Activities. These Activities situated in widely separated parts of the United States, are:

(1) Naval Air Technical Training Command—Memphis, Tennessee.
(2) Naval Air Technical Training Command—Norman, Oklahoma.
(3) Naval Training Center—San Diego, California.
(4) Naval Training Center—Great Lakes, Illinois.
(5) Naval Training Center—Sampson, New York.
(6) Naval Training Center—Bainbridge, Maryland.
(7) Naval Training Center—Farragut, Idaho.

The Training Centers at Great Lakes and San Diego were permanent installations which were enlarged during World War II. The remaining Activities were constructed in World War II along similar lines and with comparable materials There was considerable variation from station to station in the utilization of space, cleaning techniques, handling of personnel, training programs and other points of possible significance Nevertheless, the general policies and principles for handling both well and sick personnel were similar

Irrespective of size, the general plan of each installation was similar. The plan of Farragut Naval Training Center is illustrative (Figure 1). This figure shows seven individual recruit camps, the areas for Service Schools, Ship's Company and civilian personnel, and the near-by Naval Hospital. At each Activity the Naval Hospital served the station but was under a separate medical command The relatively permanent station personnel lived near, but not in recruit areas. Each recruit camp was a

distinct unit sharing only the Naval Hospital, auditoriums, chapels and certain highly specialized facilities for training Each had its own drill hall, mess hall, Ship's Service (recreation building), one or two dispensaries with wards for minor acute infections and about twenty, two-story barracks. These barracks had wooden floors, were steam heated, and contained open dormitories with double-decked bunks.

The Naval Hospital was usually a group of one-story steam heated buildings with open wards. The basic bed capacity was in most instances over 1,000 and this was increased considerably by the use of double-decked

Fig 1 The plan of a Training Center typical of those built during World War II

bunks The floors were planked and were ordinarily not covered with asphalt tile or linoleum With rare exceptions there were no cubicled beds for isolation, however, each hospital ward had one or more "quiet rooms" for critically ill patients At Great Lakes Naval Training Center the McIntyre Dispensary was designed along these lines to serve as a hospital for the recruits of this Training Center

The appearance of a sulfonamide resistant (Re)[1] strain of hemolytic

[1] Sulfonamide resistant strains will be referred to as Re strains The degree of in vitro resistance to sulfadiazine will be suffixed For example Re 25 means resistant in vitro to 25 mg % of sulfadiazine

streptococcus on a station was in most instances followed by a rapid spread not only throughout a camp but also throughout all camps where men were receiving training. There were, however, striking exceptions. For example, two sulfonamide resistant strains of type 19 did not spread at Memphis NATTC in the fall months of 1944. Furthermore, at each station the Negro trainees either escaped infections with Re strains which were epidemic on the station or experienced relatively few infections when the epidemic process was waning. At Memphis an epidemic Type 17 Re strain spread rapidly from barrack to barrack but was practically limited to one training group, the radio men. At San Diego, an epidemic type 17 Re strain caused high morbidity rates in one recruit camp but for months was not recovered in contiguous camps on the station. So far as can be determined, this difference was not attributable to the capacity of the bacterium to spread. It seems more likely that the differences in the handling of personnel and in a number of techniques used on these stations were the significant factors These can be best envisaged by examining the mode of spread of hemolytic streptococcus at several Activities.

A THE SEQUENTIAL SPREAD OF HEMOLYTIC STREPTOCOCCUS IN RECRUIT COMPANIES

At Training Centers the incidence of streptococcal infections in companies of new recruits was characteristically low during the first two weeks of training and then rose to a peak during the latter half of a training period It was not known, however, whether these streptococcal infections were caused by strains introduced by recruits on arrival or by strains already present on the station To collect information on this point, throat cultures were made of men of two recruit companies during their period of training and following their two weeks' leave at the end of training. Cultures of Group A hemolytic streptococcus were typed and tested for sulfonamide resistance. This study was made at two camps of Farragut Naval Training Center during the fall months of 1944, when sulfonamide resistant strains of type 19, 17 and 3 were prevalent. A similar study was later made at Great Lakes Naval Training Center (See Chapter XVII).

The complement of the two Farragut companies selected for study fluctuated as sick men were withdrawn and convalescents from other companies were added. The data on complement are:

	Company #865	Company #868
Total recruits in original company	100	100
Total recruits at various times	108	108
Total men dropped from original company	57	31
Total men graduated who were cultured	50	72

A summary of the findings is:

1. First week, 9–12–44: Group A hemolytic streptococcus was recovered from six throat cultures. Two were sulfonamide sensitive type 2 and 3 strains. Another was a type 19 Re 5. This strain was prevalent at Farragut in September, 1944. The culture was obtained from a man who arrived at Farragut with a "cold" and spent nine days in the Receiving Unit prior to entering the recruit camp. No throat culture had been made on arrival Group A hemolytic streptococcus was recovered from three additional throat cultures. All were sulfonamide sensitive strains but the type was not reported.

2. Second week, 9–19–44: Six additional cultures of group A hemolytic streptococcus were obtained These were type 19 Re 5, type 17 Re 25, sensitive type 19 and three group A organisms, the type and resistance of which were not reported

3. Sixth week, 10–24–44: Eighteen additional cultures of group A hemolytic streptococcus were obtained. Seven cultures were types 19 Re 25 (two), 19 Re 1 (two), 17 Re 125, 17 Re 25 and 3 Re 1. Six cultures were sulfonamide sensitive types 3, 6, 1 and 36 There were five additional cultures containing sensitive group A organisms, the types of which were not reported

4. Eighth week, 11–6–44: Thirty-two additional cultures of group A hemolytic streptococcus were obtained. Twelve cultures were types 3 Re 1 (two), 19 Re 1 (four), 19 Re 5 (three), 19 Re 25 (two) and 17 Re 25 Eight cultures were sulfonamide sensitive types NCT, 3, 1, 17 and 19 Ten cultures were types 3 (five), 19 (three), 36 and 6 with resistance not reported There were two cultures containing group A organisms, the type and resistance of which were not reported.

5 Tenth week, 11–20–44. Twenty-one additional cultures of group A hemolytic streptococcus were obtained Nine cultures were sulfonamide sensitive types NCT, 1, 3, 17 and 36 Five cultures were types 3 Re 5, 17 Re 5, 17 Re 25, 19 Re 1 and 19 Re 5 Four cultures were types 3 (two), 17 and 19 with resistance not reported. Three cultures contained group A organisms, of which the type and resistance were not reported.

6 Final week of training, 11–27–44: Nineteen additional cultures of group A hemolytic streptococcus were obtained. Eleven cultures were types 3 (four), NCT (three), 17 (two), 19 and 36 with resistance not reported Eight cultures contained group A organisms, the type and resistance of which were not reported.

7. Final cultures in original companies were made in the Outgoing Unit after two weeks' leave: One hundred and six men of these two companies were cultured again prior to transfer Twenty cultures (18 9%) contained group A hemolytic streptococcus The type and resistance of these organisms were not reported

These two companies entered training with a Group A streptococcal throat carrier rate of 1% or less. One of the six original carriers had been assigned to a receiving barrack for nine days. He developed pharyngitis four days after arrival at Farragut, Idaho and on entering a recruit training company carried type 19 Re 5. This organism was then prevalent at Farragut. It appeared that he had probably acquired this infection shortly after arrival. By the second week, type 17 Re 125 was present and during the next month Re strains of types 19, 17 and 3 were widely disseminated throughout these two companies. The peak of new implantations occurred in the eighth week. At least 68 of the original 200 men acquired the strains of hemolytic streptococcus prevalent at Farragut and 88 (42%) of these men were dropped from the companies chiefly because of streptococcal infections. A large percentage of these men were carriers of strains of Group A hemolytic streptococcus both when they returned home on leave and when they were transferred to other Naval Activities

B. CONDITIONS OF RECRUIT TRAINING CONSIDERED PREDISPOSING TO THE TRANSFER OF STREPTOCOCCAL UPPER RESPIRATORY TRACT INFECTIONS

The degree to which each recruit company became infected while in training was determined at least in part by location and season. However, irrespective of these two variables, the streptococcal morbidity rates at several stations were excessive and on occasions, alarming. These excessive rates were confined almost entirely to men in training. They were caused by pathogens already present on the station and not by bacteria introduced by new arrivals. New arrivals were exposed to unusual hazards and in many ways to contact with contagion during a training period which varied from six weeks to three months. The life history of a recruit illustrates this point:

The recruit usually arrived at a Naval Training Center after a long trip in an overheated troop train He was first given a physical examination and housed in a Receiving Barrack which was commonly overcrowded and probably seeded with epidemic strains of hemolytic streptococcus. When his company was formed he was assigned to a barrack in a recruit camp This barrack had been vacated for only a few hours prior to his entrance. The former occupants of the barrack had probably experienced a high incidence of streptococcal infections and had had a high carrier rate on departure The barrack was not cleaned or was just recently cleaned, and its dust was heavily contaminated with the prevalent strains of hemolytic streptococcus The complement of this recruit's company was not confined to new arrivals from civilian life but usually included men of earlier companies who were convalescent and were still carriers of hemolytic streptococcus. This resulted in exposure of the recruit to hemolytic streptococcus within his barrack, both by direct contact with human

carriers and through the inhalation of contaminated floor dust. This exposure to contaminated floor dust was increased by the Naval cleaning technique for the polishing of floors Rubbing with "steel wool" and then dry sweeping was done during the day and frequently just before bed time when the barrack was crowded and the windows were all closed Crowding of the barrack to 50% above the planned capacity was common, owing in part to sudden rapid expansion of training programs and in part to failure to use all available barracks. The air temperature within the barracks was generally higher and the humidity lower than those to which the recruit had been accustomed in civilian life.

Other physical adaptations had to be made during the early weeks of training The recruit had to learn to swim in an indoor pool of warm, chlorinated water and then stand "outdoor watches" in fog, rain, snow or freezing temperatures Some of these "watches" occurred during the night when he was accustomed to sleep The hours of sleep were usually less and the rising hour earlier than those to which the average recruit was accustomed While becoming adjusted to these strains, he underwent physical reactions following immunizations against small pox, typhoid fever, tetanus and yellow fever

Exposure by direct contact to hemolytic streptococcus soon occurred within his barrack. Older recruits from other companies were discharged from the hospital and while convalescing from streptococcal infections were assigned to the barrack of the new recruit. Furthermore, company mates in the early stages of respiratory infections had visited the dispensary, had been seen by a hospital corpsman and, because of the low degree of fever and absence of rash, had returned to the barrack only to develop scarlet fever the following day Other company mates with streptotoccal pharyngitis and little fever were diagnosed as having "catarrhal fever" by hospital corpsmen and had also been returned to the barrack Within the barrack the new recruit became exposed to an increasingly large number of men with streptococcal diseases

Outside of the barrack the new recruit mixed with men in various stages of recruit training These men occupied other barracks but shared the same recreation building, drill hall and dining hall Furthermore, they used the same gas masks at drills and occupied the same class rooms as the new recruit If the new recruit escaped streptococcal infection in the barrack, he probably contracted a "bad cold" and reported to the dispensary at Sick Call There he came into contact with a large number of men in the early stages of streptococcal diseases

C. LINKS IN THE CHAIN OF SPREAD OF RE STRAINS ON A NAVAL STATION

The U S. Navy grew during World War II to more than twice the size originally planned This expansion required a comparable increase in

medical officers. However, physicians were not readily available; the Medical Corps was markedly undermanned; demands for overseas assignment received priority. The result was a chronic shortage of medical officers at Naval Training Centers. This shortage was felt most during the seasons when communicable diseases were prevalent. For example, at Farragut in the fall months of 1943 the station population was about 60,000 and there were only 15 medical officers to handle the administrative and clinical problems In the fall months of 1944 there was a similar acute shortage which required the immediate transfer of 28 physicians to Farragut. This situation obtained also at other training centers Since there were not enough medical officers to man the dispensaries of each recruit camp several training centers closed one of the two dispensaries in each camp. Sick Call for about 5,000 recruits was then held in a single dispensary. With only half of the dispensaries in operation epidemics of streptococcal infections occurred not only at Farragut but also at Sampson and Bainbridge.

1. *The Camp Dispensary:* Data were not available on the number of men who attended Sick Call because of a "cold" and returned with scarlet fever a few days later. However, this was recognized to be a common experience. Furthermore, on at least one occasion, an outbreak of diphtheria occurred in three companies attending Sick Call with a man who had diphtheria. Patients from these companies were confined in the dispensary ward with men later found to have diphtheria. Exposure occurred at Sick Call and later in the ward (12).

The camp dispensary was adequate in design to care for a moderate number of men at Sick Call and for the bed care of men with non-communicable diseases. The effective functioning of a dispensary ceased when minor respiratory complaints became prevalent. At these times, men were crowded together in line within a narrow corridor for hours where they waited to be examined. The recruit with a minor surgical complaint or a reaction to typhoid inoculation was brought into close contact with scarlet fever patients at Sick Call. Furthermore, febrile recruits were packed close together in the double decked bunks of the dispensary wards irrespective of whether they had streptococcal infections Bacteriologic studies showed that the floor dust of wards and corridors in the dispensary became heavily seeded with Group A hemolytic streptococcus.

It was not uncommon during the winter months for the daily dispensary sick call to exceed 500 men. All of these men were seen by hospital corpsmen but only those obviously ill were examined by the dispensary medical officer. The corpsmen took oral temperatures of all men with a few thermometers which were either wiped off with an alcohol sponge or dipped into a bottle of alcohol and then passed from mouth to mouth as rapidly as

possible In most instances, the corpsmen decided on the basis of the febrile reaction whether a man should return to duty, rest in his barrack or see the dispensary physician who admitted the patient with a frank streptococcal throat infection to his dispensary wards unless there was a scarlatiniform rash In this case, the patient waited and was transferred to the Naval Hospital. Sick Call provided direct contact between sick men from many barracks Furthermore, indirect exposure to the organisms already seeded in the floor dust occurred when dispensary floors were dry swept just prior to or during Sick Call

The recruit who came to the dispensary with "a cold" was exposed to inoculation with hemolytic streptococcus when he was treated by the corpsman The corpsman, wishing to relieve the patient's symptoms, usually applied a nasal spray to shrink the mucous membranes A mist was supplied in some instances from nebulizers, the tips of which often went from one man's nostrils to another's without being sterilized Furthermore, most dispensaries were equipped with instruments for forcing mists into the nares under positive pressure The stock instruments used from the Navy supply were number S6-220 (Cabinet Specialists Treatment 110 volt 60 cycle AC) or number 6-090 (Compressor, air, electric tankless 110 volt AC-DC). The jets and adapters were rarely sterilized during periods of heavy Sick Calls Most of the solutions used for the relief of symptoms were in bottles with jets attached. Many of these solutions were bacteriostatic However, this was not true of a solution of Neosynephrin sprayed into the naso-pharynx of large numbers of men, which contained a pure culture of type 17 Re 25. This strain had given rise to an epidemic of scarlet fever at Great Lakes Rapid mass inoculation of men from all barracks of a camp with a highly pathogenic organism was made possible by this widely used technique of injecting solutions intranasally through pressure sprays Crowding, the inhalation of contaminated dust and nasal sprays made Sick Call an effective mixing bowl for all respiratory pathogens within the camp.

If the recruit appearing at Sick Call was found to have an erythematous rash in addition to an inflamed pharynx, he was transferred to the Naval Hospital by ambulance. Because of the shortage of ambulances, he shared this transportation with men having measles and other communicable diseases The camp dispensary appeared to be probably the most important link in the rapid spread of streptococcal infections from a barrack throughout a camp

2 *The Station Hospital* A Naval Hospital served each training station, it cared for men with surgical disorders, major medical problems and communicable diseases. Streptococcal nasopharyngitis was treated in the wards of camp dispensaries, however, scarlet fever was treated in the

hospital's contagious disease wards which with few exceptions were open and without cubicles. In hospitals with cubicles, the number of isolation beds was adequate for only a small proportion of the cases that occurred during an outbreak of scarlet fever. Furthermore, during the winter months these wards frequently had double-decked bunks and crowded with single beds in the center aisles. On one day each week (Field Day) all beds were moved around so that the ward could be polished for inspection. This cleaning process placed patients with different diseases in close proximity to each other. There were no facilities for the handling of contagion and no consideration could be given to prevent cross-infections. Serial studies made of the bacterial throat flora of recruits on entering and leaving the contagious disease wards of four Naval Hospitals, showed that at least 25% were cross-infected and that they carried back to their camps streptococcal strains different from those with which they had been infected prior to admission to the hospital.

On recovery from scarlet fever, the patient was not returned to his original company. He entered a new company of recruits who were in the same stage of training that he had been when scarlet fever was contracted. The effect of seeding convalescent streptococcal patients in a new company was determined in the following way:

A segregated company free of the prevalent types of hemolytic streptococcus happened to be seeded with twelve men discharged from the scarlet fever wards of the hospital Six of these 12 scarlet fever convalescents were carriers of Group A sulfonamide resistant strains of types 3 and 17. Approximately one week later three men barracked in close proximity to one of the carriers of type 3 developed scarlet fever. The throat Re strain was in each instance indistinguishable from that of the convalescent carrier. A sulfonamide resistant type 3 strain of hemolytic streptococcus had been introduced into this barrack. Men contracting this infection with a rash were transferred to the Naval Hospital, however, those who failed to develop a rash were treated in the camp dispensary or in the barrack Sulfonamide resistant type 3 hemolytic streptococcus, which was introduced into this barrack from the Naval Hospital, subsequently spread throughout this camp. Our findings are in accord with those of Lemon and Hamburger (7)

SUMMARY

Observations indicate the points within a training center at which a new recruit may be exposed to hemolytic streptococcus.

Sulfonamide resistant strains of hemolytic streptococcus were introduced by Outgoing Unit personnel from several Naval Activities into Service Schools When Service School men with scarlet fever came into

close contact with recruits in the hospital wards, the contacts carried Service School strains of hemolytic streptococcus back to recruit camps barracks. These strains were spread rapidly throughout a camp by men attending Sick Call at the camp dispensary and throughout the station by convalescents returning from the scarlet fever wards of the hospital

In brief, the dispensary appeared to be an intra-camp "mixing bowl" which gave rise to the rapid passage of infections to all barracks of the camp and the Naval Hospital appeared to be an intra-station "mixing bowl" which made possible the spread of highly communicable strains of hemolytic streptococcus throughout all camps of the training station.

CHAPTER IV

THE DEVELOPMENT OF FOCAL POINTS OF STREPTOCOCCAL INFECTIONS EARLY IN WORLD WAR II

The dangers of devastating fires are widely recognized and much attention is given to protection against their spread Furthermore, it is the rule for civilian, government and military groups to spend generously on insurance against damage by flames Fires still occur; however, their spread is now usually limited by effective control measures. The establishment of these control measures did not develop by accident. They were effected through evaluation of the problems, planning in advance, institution of sound controls and adequate expenditures for combative equipment and personnel. Expenditures made for the prevention of and insurance against destructive fires have proved their survival value in the national economy. The damage to man caused by fire is now small in comparison with the results of epidemic diseases.

Prior to the nineteenth century, the menace of a devastating disease was not widely appreciated until an epidemic had occurred. However, in recent years and especially since the influenza pandemic of 1918, intense research has been directed to the development of measures to prevent outbreaks of respiratory tract infections. Yet streptococcal epidemics have continued to occur and have proved devastating to the economy, health and life of man The genesis of these outbreaks has been unpredictable During recent decades hemolytic streptococcus manifested only mild activity General concern became lulled; time-consuming and expensive control measures seemed unnecessary Conditions resulting from military training brought an increase of streptococcal activity in the war years By that time, the spread of hemolytic streptococcus had already been facilitated by lack of preparedness, isolation facilities and combative man power In final analysis, the measures instituted to check the epidemic process were "too little and too late"

That this need not be the case has been demonstrated in recent years in hospital obstetrical wards The survival of an institution for the care of obstetrical patients has depended on eternal vigilance against puerperal sepsis. Exercising control measures against streptococcal infections in obstetrical wards has been expensive and for years outlays may have seemed uneconomical. Nevertheless, these control measures have survived because they proved effective and were well worth the cost.

Increasing streptococcal activity was apparent in the U. S. Navy during training programs instituted just prior to the onset of World War II. Wheeler and Jones (13) studied an outbreak at the U S. Naval Training Station at Newport, R. I. in the winter and spring of 1940 and 1941. They observed that hemolytic streptococcus type 6 gave rise to a high incidence of scarlet fever, that the incidence of infections was much higher in recruits than in permanent personnel, that the highest incidence occurred among men occupying a barrack which had the highest bacterial counts in the air including type 6 hemolytic streptococcus This outbreak, occurring in the wake of a wave of mild influenza, reached a degree of intensity that required suspending the admission of recruits for six weeks in March and April

Early in World War II streptococcal activity became intense at another permanent training station of the U. S Navy Scarlet fever and rheumatic fever caused high morbidity rates at the Great Lakes Naval Training Center during the winter and spring months of 1942

Later in 1942 several large centers were opened for the training of Navy recruits Like Newport and Great Lakes, they were located in the northern part of the United States. Each soon experienced severe outbreaks of streptococcal disease. At Bainbridge, Maryland, Hodes, Schwentker and their collaborators (14) showed that the first Group A streptococci to become predominant were types 6 and 1. In contrast to the findings at Newport, this type 6 produced throat infections without a high incidence of scarlet fever At Sampson, New York the first spring months of training were accompanied by a high incidence of scarlet fever At each of these stations streptococcal activity was seasonal. The incidence of scarlet fever reached a peak in the spring months and the disease disappeared during the summer months. However, there was one station at which hemolytic streptococcus maintained a high degree of activity throughout the year This was the Naval Training Center at Farragut, Idaho, situated in the Rocky Mountains a few miles south of the Canadian border Within its first year this station became a tremendous reservoir of hemolytic streptococcal diseases. Subsequent events showed that this center developed into perhaps the most important focal point from which streptococcal infections were spread throughout the Navy The history of this development at Farragut is divided into three phases·

Phase 1 Recruit training began at Farragut in the fall of 1942 For three months the incidence of acute streptococcal infections remained within moderate limits However, streptococcal morbidity rates soon rose slowly and progressively At the

Phase 2 An outbreak of measles occurred early in 1943 This was followed by a rapid rise in morbidity rates for streptococcal diseases in all recruit camps at Farragut. By April, the incidence of acute streptococcal infections was higher than at any other U S. Naval Training Station This was the "dissemination" phase Epidemic strains were spread throughout the station

This was the beginning of an epidemic process that was perpetuated through December, 1944 In addition to factors previously noted (Chapter III) other conditions which may well have facilitated the spread of hemolytic streptococcus throughout this long period were briefly

(a) With acceleration of the training program in 1943 fresh recruits were added weekly in larger numbers to each camp The turnover of men was increased as the training period was shortened and the transmission of respiratory pathogens from man to man was constantly accelerated

(b) Strains of hemolytic streptococcus appeared to acquire progressively greater infectivity. In one month during the winter of 1943, 7% of all personnel were on the Sick List and on occasions during 1943 there were 4,000 men ill in bed This high morbidity was due chiefly to streptococcal infections The ratio of these infections among groups of personnel was Recruits' camps 26, Service School, 7, Ship's Company, 2 The highest incidence of infections at this time occurred between the third and seventh week of recruit training

(c) Hospital and dispensary facilities, which became available for approximately 1500 bed patients in the winter of 1943, were soon overtaxed Medical personnel became more and more taxed in their effort to handle the tremendous numbers of men at Sick Call The application of aseptic precautions was not possible in dispensaries. As noted, barracks in the recruit camps were needed for incoming trainees on the day that they became empty, and it was not possible to air or clean them between the departure of old and the arrival of new recruits

(d) A vicious cycle initiated late in 1942 and accelerated in the winter of 1943 could have been expected to progress until June If hemolytic streptococcus had lost its pathogenicity in the summer months, the epidemic cycle would have been broken spontaneously However, this did not occur in northern Idaho during the summer of 1943, and the epidemic state was intensified

(e) Barrack space for the Outgoing Unit was limited to 2,000 men In 1943 the roster for this Unit rose to over 10,000 Larger groups of men were quartered in drill halls and in drained swimming pools Morbidity rates were high, large numbers of outgoing men became ill in transit to other stations, the arrival at distant points of transfers from Farragut Outgoing Unit was followed by outbreaks of scarlet fever. Hemolytic streptococcus was in this way disseminated from Farragut to other Naval Activities

Phase 3 Streptococcal morbidity rates, which had fallen moderately during May and June, 1943, began to rise early in August This mid-summer streptococcal outbreak appeared to be "contra-seasonal" and was particularly conspicuous since streptococcal activity at all other Naval recruit training centers was minimal This is shown in Table 1 The streptococcal epidemic curve climbed progressively from July to December 1943 During the first week of December, 1943, the morbidity rate per 1,000 per year for scarlet fever reached the extraordinary peak of 313, the highest ever recorded at Farragut

The *total morbidity* from streptococcal infections during 1943 at Farragut was alarming In one year this training center with an average strength of 43,000 had 4,973 cases of scarlet fever, 1,375 cases of rheumatic fever and a tremendous number of cases classified as tonsillitis, pharyngitis and "catarrhal fever" In December and

January this bacterium caused approximately 200 cases of primary streptococcal pneumonia with empyema, pericarditis or lung abscess This syndrome only rarely observed in the United States since the pandemic of 1919 began to spread to other activities The agents responsible for these infections were identified as hemolytic streptococcus types 17, 19, 1 and 3 In one year these strains had become widely disseminated throughout the station; they were both highly communicable and highly pathogenic, they were transmitted within two weeks to incoming recruits, they appeared to give rise to streptococcal outbreaks at distant Naval Activities that received transfers from Farragut.

FARRAGUT: THE ONLY DANGEROUS FOCAL POINT THROUGHOUT ALL MONTHS OF 1943

Hemolytic streptococcus caused more than 47,000 infections among Naval personnel during 1943 and the morbidity rate for scarlet fever reached a level higher than previously recorded in the history of the U. S. Navy Focal outbreaks appeared at many points during the spring months in the northern states Type 19 was the causative agent in an outbreak of

TABLE 1

The Incidence of Scarlet Fever during Summer Months at Naval Training Centers

Annual Rate per 1,000 for Six Months of 1943 and 1944

NTC	1943					1944				
	June	July	Aug	Sept.	Oct	June	July	Aug	Sept	Oct
Farragut, Idaho	85	69	88	126	150	50	64	94	250	202
Great Lakes, Illinois	35	3 6	0 15	0 45	4 1	7 2	3 7	2 13	9	32
Sampson, New York	11	3 5	0	0	1 3	0 86	0	0	0	8 3
Bainbridge, Maryland	2 9	1 1	0	0	0 80	3	0 36	0 38	0	1 6

scarlet fever at The New York Receiving Ship on Pier 92 (15) Great Lakes Naval Training Center experienced a scarlet fever epidemic caused principally by type 17 and to a lesser degree by types 1 and 30 At Navy Pier, Chicago, type 3 was predominant in a wide variety of streptococcal infections Types 19, 18, 14 and 27 were also recovered Irrespective of the intensity and extensiveness of these infections, streptococcal activity subsided during the summer months at all Navy stations but one As previously noted at Farragut, Idaho, in August 1943, the morbidity rate for scarlet fever began a sharp rise which was progressive throughout the year 1943

High morbidity rates at Farragut were, however, not confined to streptococcal infections Other bacterial and virus infections of the respiratory tract occurred in large numbers The 1943 morbidity data for several respiratory tract infections at Farragut and at all other training centers are presented in Table 2.

TABLE 2

Annual Rate per 1000 by Months—Farragut N T C and Other Training Centers—1943

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct.	Nov.	Dec.
Scarlet Fever	NTC Farragut	5.8	7.6	12.3	48	120	85	60	88	126	150	147	210
	NTC All Others	33	52	83	97	82	16	2	0.12	0.35	2	11	29
Rheumatic Fever	NTC Farragut	—	—	—	33	25	13	13	7.5	17	25	36	29
	NTC All Others	79	2	6	9	10	7	4	2	2	2	1	1
Pneumonia B/A	NTC Farragut	15	10.7	8.5	19	22	12	5.1	4.7	15	14	21	31
	NTC All Others	15	15	12	15	18	9	9	8	10	12	12	17
Cerebrospinal Fever	NTC Farragut	1.6	1.0	2.1	7.0	2.4	2.7	0.27	—	0.24	0.44	—	—
	NTC All Others	2	2	3	4	6	2	1	0.90	0.65	0.52	0.67	1
Catarrhal Fever	NTC Farragut	1185	618	1016	1074	846	421	354	265	263	382	576	595
	NTC All Others	821	583	529	500	503	251	184	139	165	205	495	509
German Measles & Measles	NTC Farragut	80	187	121	119	46	25	11	9.7	0.47	0.67	2.9	18
	NTC All Others	140	200	130	115	85	16	4	2	2	2	2	9
Mumps	NTC Farragut	16	36	62	129	127	80	43	25	21	10	19	35
	NTC All Others	16	19	25	22	30	11	10	4	3	2	3	5

It is seen in Table 2 that:

(a) Scarlet fever rates reached a peak at Farragut in May 1943 and then fell until August. Throughout the remainder of the year the rate varied between 400% and 40,000% higher than the combined rates for other training centers.

(b) Rheumatic fever was first reported from Farragut in April, 1943, when it was 270% higher than the combined rates for other training centers. By November it was 3500% higher.

(c) Pneumonia reached high morbidity levels during November and December, 1943, when the morbidity rates were 80% higher than those of other training centers

(d) "Catarrhal fever" rates were excessive at Farragut every month of 1943. In February, this rate was only 6% higher, but by July it was 95% higher than the rates for other training centers

(e) Mumps rates at Farragut were comparable to other training centers in January, 1943. After January the morbidity rates were between 500 and 600% higher than the combined rates for other training centers

These morbidity data suggested that conditions at Farragut favored the dissemination of air-borne respiratory tract pathogens, especially some of the gram positive bacteria and certain viruses.

The ecology of *Streptococcus hemolyticus* in the Rocky Mountains is unknown Conditions created in World War II indicate that the bionomics of this bacterium in Northern Idaho may be unusual In other environments where Naval Activities were located, epidemic strains of hemolytic streptococcus tended to lose their pathogenicity with the onset of summer weather However, the clinical and bacteriologic observations made throughout two summers at Farragut showed that the incidence of streptococcal infections remained relatively high Hemolytic streptococcus maintained its pathogenicity In fact, it appeared that the "epidemic capacity" of this bacterium was increased in August 1943 and again in July 1944 These "contra-seasonal" changes are shown in Figure 3, Chapter II.

SUMMARY

Whatever may be the relation of cosmic forces to the epidemicity of Group A streptococcus and to the susceptibility of the human host, it seems clear that some factor or factors in environment may increase streptococcal activity

This was striking at Farragut, Idaho, where the communicability and pathogenicity of hemolytic streptococcus were maintained throughout all seasons of the year

Early in World War II the Farragut Naval Training Center became the focal point most likely to disseminate highly communicable and highly pathogenic strains of hemolytic streptococcus throughout the Navy

CHAPTER V

PRELIMINARY OBSERVATIONS ON THE SPREAD OF CONTAGION FROM FOCAL POINTS TO DISTANT STATIONS

A. EARLY FINDINGS

Approximately 5,000 cultures of hemolytic streptococcus were identified serologically during the winter and spring months of 1944. The results are presented in Table 1. These cultures were obtained from 16 Naval Activities situated in all sections of the United States. The most prevalent types were 19 and 17 The bacteriologic picture differed at each of the large training centers and individual variations occurred at smaller stations. One outbreak in Pennsylvania was caused by type 30; another near the District of Columbia by types 14 and 3. At Bainbridge, Maryland, type 19 was predominant, and type 18, which had been rarely observed elsewhere, was second in predominance. Naval Activities in New York and Rhode Island had no predominant type In Illinois, at the Great Lakes Naval Training Center, there was also no predominant type; the types *prevalent were 5, 17, 19, 3 and 1 Type 5 was prevalent only at Great* Lakes. Epidemics at Farragut, Idaho were caused by types 17, 19, 1 and 3.

As early as 1943 reports were received from Naval stations which indicated that drafts of men from Farragut, Idaho were spreading streptococcal infections following their arrival at distant points. These reports indicated that Farragut transfers had developed streptococcal infections in transit and on arrival, that the streptococcal carrier rate was high among these men, that outbreaks of streptococcal infections occurred in the barracks of the station to which these transfers were admitted. The suggestion that Farragut infections were being disseminated to other Naval Activities was investigated by typing the streptococci of Farragut men and men on the stations to which they were transferred. In the winter of 1944, nine stations received most of the Farragut Outgoing Unit drafts Cultures of hemolytic streptococcus were obtained from acutely ill men on these stations and identified at the Typing Laboratory in Bethesda. Types 17 and 19 were found to be prevalent in all nine of these Naval Activities, type 1 in seven Activities and type 3 in three Activities. The types of hemolytic [illegible] lent at Farragut were thus also prevalent at the stations

TABLE 1

Serologic Types of Hemolytic Streptococcus at Naval Training Stations—1944

Type	Bainbridge	Farragut	Great Lakes	Sampson	Other Activities	Total
1	87	108	54	11	34	294
2	4	0	2	3	3	12
3	26	61	72	48	28	235
4	0	2	1	2	0	5
5	28	4	94	29	6	161
6	28	22	23	30	18	121
8	0	1	0	1	3	5
9	0	3	1	1	0	5
11	0	0	0	2	0	2
12	27	7	12	34	10	90
13	1	0	1	3	1	6
14	5	22	0	4	23	54
15	0	0	0	0	0	0
17	69	305	95	26	93	588
18	85	10	1	4	4	104
19	392	342	78	15	128	955
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	36	25	6	12	6	85
26	0	0	7	7	4	18
28	4	4	0	2	2	12
29	6	0	0	2	0	8
30	30	1	3	21	12	67
31	0	0	0	0	0	0
32	0	0	3	2	0	5
33	2	2	1	2	0	7
36	4	20	6	2	16	48
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	3	2	0	5
40	0	0	0	0	0	0
41	3	2	2	9	1	17
42	0	0	0	0	0	0
43	2	0	1	2	0	5
44	2	2	1	3	1	9
46	1	0	1	0	2	4
?	134	111	64	168	87	564
Not Group A	258	135	104	394	178	1,069
Total	1,234	1,189	636	841	660	4,560

Subsequent reports called attention to the fact that many men in transit from recruit training centers were either in the acute stage or in the incu-

bation period of streptococcal infections. It was observed repeatedly that men from Great Lakes had scarlet fever and tonsillitis on arrival at the Radio Schools in Chicago and at the Navy Armory in Indianapolis. These Naval Activities were located between 50 and 200 miles from Great Lakes Three illustrative examples of these reports are as follows:

(a) From Portland, Oregon: "An unusual number of admissions not shown in our statistics came from Farragut, Idaho, personnel on leave or passing through Portland. These men were mostly cases of scarlet fever, many of whom were taken off trains at the station by our ambulance." Portland is about ten hours by railroad transportation from Farragut.

(b) From the Radio School in Madison, Wisconsin: "It is noted that five of the fifteen cases of scarlet fever reporting to Sick Bay at this activity since 1 January, 1945, developed their diseases within five days after reporting at this station from Great Lakes." Madison is about 100 miles from Great Lakes

(c) From Gulfport, Mississippi "Of the two hundred and sixty six-cases of scarlet fever, eighty-two cases broke out within one week of arrival at Gulfport, twenty-eight being diagnosed on the day of arrival." Forty-nine of these cases came from Great Lakes the remainder came from other training stations All of these stations were distant

These observations suggested that men in the Outgoing Units of training centers were being infected and were spreading infections.

AT NAVY TRAINING STATIONS

Descriptions of the conditions in Outgoing Units of two training stations serve to indicate the possibilities for the spread of contagion among men being transferred to other Naval Activities.

(a) Great Lakes· As late as the spring months of 1945 the Outgoing Unit of Great Lakes was handicapped by the shortage of medical personnel, lack of barracking space and inadequate dispensary facilities The Unit was housed in congested, triple-bunked quarters. One "barrack" which billeted 2,500 men was a poorly lighted hangar with a concrete floor. Personnel of the Outgoing Unit shared with Marines and Service School men a one-story dispensary which was planned to handle the illnesses of about 2,000 recruits but under war time conditions had to care for 15,000 men. During February and March, 1945, over 2,000 men were admitted to the Sick List from this dispensary Transportation facilities were good and about 5,000 men were detached each week from the Outgoing Unit. However, neither the medical personnel nor the dispensary facilities were adequate for the proper examination of these men prior to departure

(b) Farragut: Railroad transportation for large drafts of men leaving Farragut, Idaho was inadequate in 1943 and 1944. The problem of prompt

disposition of personnel who had finished recruit training was unsolved in the first eighteen months of this station's service. In 1943 buildings were erected to billet the Outgoing Unit. However, when crowded, they billeted only 2,000 men. As previously noted, in October 1943, there were between 11,000 and 13,000 men in the Outgoing Unit. The majority of these men were of necessity billeted in drill halls, and even in drained swimming pools. Frequently these men waited weeks or months for transfer No medical facilities were available for this large unit and it was physically impossible to screen these men for streptococcal throat infections just prior to detachment.

C. BACTERIOLOGIC OBSERVATION ON STREPTOCOCCAL RESERVOIRS IN OUTGOING DRAFTS

Studies were made on the contamination of Outgoing Unit men and their gear to determine the mode of spread of streptococcal diseases Findings at two stations were illustrative of the observations collected.

(1) Sampson, New York: The contamination of blankets among members of the Outgoing Unit was checked at this Activity The culturing technique used at Farragut (described on page 124) was followed Cultures were made from a random sample of 50 blankets just as Sampson men were leaving the station. For comparison cultures were also made on a random sample of 50 blankets belonging to arrivals from the Great Lakes Outgoing Unit just as these blankets were taken out of the sea bags In brief, it was found: (a) that nineteen of 50 Sampson blankets (38%) were contaminated with Group A hemolytic streptococcus when the men left Sampson, and (b) that twenty of 50 Great Lakes blankets (40%) were contaminated with Group A hemolytic streptococcus when these men arrived at Sampson

(2) Farragut, Idaho: It was not until late in the war that congestion of members of the Outgoing Unit was relieved Screening of men for throat infections and investigation of their gear became practicable and in February, 1945, just prior to detachment, nose, throat and blanket cultures were taken from an unselected sample of 100 men in the Outgoing Unit to determine (a) whether these men carried strains of hemolytic streptococcus in the upper respiratory tract, (b) whether their personal effects, especially their blankets,[1] were a reservoir of respiratory pathogens, or (c) whether both men and gear were contaminated Twenty-two of these men had had upper respiratory tract infections within the previous month and 16 of these still had evidence of infection None of the other 78 men had a

[1] Blankets are issued to enlisted personnel on the day of arrival and carried by them throughout their life in the Navy More bacteriologic studies of personal effects are presented on page 127

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level since the opening of the station. Living conditions for the Outgoing Unit were excellent at the time of this study. Nevertheless, there was a high degree of contamination with Group A hemolytic streptococcus. In another Farragut study it was shown that the throat cultures of men leaving this station contained sulfonamide resistant strains of hemolytic streptococcus and that type 17 Re 125 strains and type 19 Re 25 strains had been present each week in the throat flora of these men for over two months

In summary, it appeared that either men or their equipment may have served as a means of transmitting Group A hemolytic streptococcus from one Naval station to another.

D. APPLICATION OF THE SULFONAMIDE RESISTANCE TEST AS AN ADJUNCT TO SEROLOGIC TYPING IN DETECTING THE SPREAD OF HEMOLYTIC STREPTOCOCCUS

Opportunity to make convincing observations on the spread of hemolytic streptococcus from training stations to a distant point came as a by-product of the use of mass chemoprophylaxis in the U S. Navy. Observations on the use of sulfadiazine prophylaxis were summarized in June 1944 at the end of a six months' trial (16) At that time it was pointed out that since prophylaxis was not 100% effective there was a possibility that some hemolytic streptococci were resistant to a sulfadiazine blood level of about 1 mg % This possibility was strengthened by the finding that type 19 had become prevalent during the spring months of 1944 at Farragut, Idaho However, definite information on streptococcal resistance to sulfonamides had to await the development of a medium which would not only support the growth of Group A hemolytic streptococcus but also be free of sulfonamide inhibitors A satisfactory medium[2] for testing the sulfonamide resistance of hemolytic streptococcus in vitro was made available by Commander Armine T Wilson during the summer months of 1944

Collect[illegible]

that types 17, 19 and 3 included not only sulfonamide sensitive strains but also resistant strains Some of the latter were resistant to 1 mg %, others to 5 mg %, others to 25 mg %, others to 125 mg % or stronger concentrations of sulfadiazine. Furthermore, so far as could be determined, the resistance to sulfadiazine appeared to be a characteristic of the bacterium that did not change in the human host, in animal passage, in serial transfer, or in storage at ice box temperature

Cultures which had been collected from a large number of training Activi-

[2] Based on the medium of Adams and Roe

history of recent respiratory tract disease and appeared in good health. The results of the cultures of men and blankets are shown in Tables 2 and 3.

The data cited in Table 3 were analyzed statistically (by application of the formula for significant differences between the observed percentages of positive and negative results in the two categories) and it was found that the difference in the results between those men ill or recently ill with respiratory disease and those who had had and were in good health could easily have occurred by chance. Therefore, all men were considered members of the same universe in Table 3

TABLE 2

Results of Nose, Throat, and Blanket Cultures of 100 Men in Outgoing Unit

	Blankets +	Blankets −	Totals
Throat +, Nose −	18	16	34
Nose +, Throat −	1	1	2
Throat −, Nose −	29	27	56
Throat +, Nose +	7	1	8
Totals	55	45	100

TABLE 3

Results of Nose, Throat, and Blanket Cultures of 100 Men in Outgoing Unit

Results	Men with Recent Respiratory Infections		No History of Illness		Total	Percent of Total
	Number	*Percent*	*No*	*Percent*		
N−, T−, B−	5	22 7	22	28 2	27	27
N+, T+, B−	0	0	1	1 3	1	1
N+, T−, B+	0	0	1	1 3	1	1
N−, T+, B+	4	18 2	14	17 9	18	18
N−, T−, B+	10	45 5	19	24 4	29	29
N−, T+, B−	2	9 1	14	17 9	16	16
N+, T+, B+	1	4 5	6	7 7	7	7
N+, T−, B−	0	0	1	1 3	1	1
Totals	22	100	78	100	100	100

It is seen from Table 2 that Group A hemolytic streptococcus contaminated 55% of the blankets The incidence of positive throat cultures was 42% and of positive nose cultures 10%. Further observations on this point were reported in Chapter XVI, page 126

made at Farragut suggest that these strains may have been present and unrecognized at this station, until they became prevalent. Whether they were present in 1943 will not be known because only four cultures were available for testing These four strains were sulfonamide sensitive. Since a large number of Naval personnel were transferred from Farragut to Treasure Island and since virtually no personnel were sent from Treasure Island to Farragut, it seems reasonable to assume that the Re strains made their appearance first at Farragut, Idaho

1 Observations at Farragut · The streptococcal morbidity data for 1943 indicated that Farragut was the Naval Activity most heavily contaminated with hemolytic streptococcus The typing results of 1,189 cultures obtained during the first five months of 1944 at Farragut showed that types 19, 17, and 1 predominated. Types 3, 24, 6, 36, 18, 12, 5, 4, 28, 41, 44, 9, 8 and 30 were also present in the camps of this station The in vitro resistance or sensitivity of these types of hemolytic streptococcus to sulfonamide could not be determined because a method for testing resistance had not yet been developed. Unlike all other stations, Farragut continued to have scarlet fever throughout the summer months of 1943 and 1944 With continuous passage of strains from man to man throughout all months of the year, three types acquired a great degree of pathogenicity and communicability. Of all the U S Navy stations none was theoretically more favorable for the selection of resistant mutants of types 19, 17 and 3.

Five hundred and sixty Farragut cultures were typed in October and November 1944 The predominating organisms were classified as types 19, 17 and 3. Most of these organisms were sulfonamide resistant Other types recovered were 1, 6, 12, 4 and 36. At least three sulfonamide resistant strains of type 19, in addition to the sulfonamide sensitive type 19, were identified They were in order of prevalence strains Re 25, Re 5 and Re 1. There were also at least three Re strains of type 17 in addition to the relatively rare sulfonamide sensitive type 17 They were in order of prevalence Re 125, Re 25 and Re 5 There were also at least three Re strains of type 3 in addition to the sensitive type 3 They were in order of prevalence· Re 5, Re 1 and Re 25.

As a result of the high incidence of streptococcal infections in September 1944, and the in vitro evidence that the prevalent organisms were sulfonamide resistant, the number of incoming recruits was lessened The transfer of Farragut men to other Naval Activities was, however, not discontinued. The possibility that these men might disseminate sulfonamide resistant strains of highly communicable organisms caused deep concern

2 *Observations at Treasure Island Naval Hospital* The in vitro studies made during the fall of 1944 showed that types 19 and 17 sulfonamide resistant organisms were present during the summer months in the San Francisco area

ties were tested for sulfonamide resistance between September and December 1944. There were two significant findings: Those obtained from stations east of the Rocky Mountains were sulfonamide sensitive. However, a few cultures obtained during the summer of 1944 from Treasure Island, California and a large number from Farragut, Idaho were in most instances sulfonamide resistant. All but three of 37 cultures obtained between August and October at Treasure Island were found to be sulfonamide resistant strains of types 19 and 17. Tests of Farragut cultures which had been obtained in June were made in September. It was found that all but two of 42 type 19 (the predominant type) cultures were sulfonamide resistant; 12 type 17 cultures were sulfonamide resistant; all but two (type 3) of 18 cultures of other types were sulfonamide sensitive. Most of the Farragut cultures obtained in August and September were also sulfonamide resistant; all 32 type 19 cultures were resistant; all 13 type 17 cultures were resistant, five type 3 cultures were resistant; 14 cultures of various other types were sulfonamide sensitive These laboratory studies supplied convincing evidence that some of the streptococcal infections at Treasure Island, where the streptococcal morbidity rate was low in the late summer of 1944, had been caused by sulfonamide resistant organisms of two serologic types, and that sulfonamide resistant streptococci of three types caused most of the streptococcal infections that reached epidemic proportions at Farragut in the summer of 1944

The fact that the large recruit training center at Farragut continued to send large drafts of men to many areas of the United States and the fact that Farragut transfers in the past had apparently spread streptococcal infections to other Naval Activities made it seem likely that sulfonamide resistant strains would be transferred to Naval installations throughout the United States

Streptococcal morbidity rates were low at all Naval Activities, except Farragut, in the fall months of 1944 The streptococcal infections which did occur at the other Activities were caused by many serologic types including 19, 17 and 3 However, all of these organisms were found to be sulfonamide sensitive in vitro. Since no Re strains appeared to be present at the Naval Activities east of the Rocky Mountains and since sulfonamide resistance could be determined in the laboratory, it seemed that the resistance test would prove an adjunct to serologic typing in tracing the spread of Re strains.

E OBSERVATIONS ON THE FIRST APPEARANCE OF RE STRAINS OF HEMOLYTIC STREPTOCOCCUS IN THE U. S NAVY

The origin of the sulfonamide resistant strains of hemolytic streptococcus which were prevalent both at Farragut and Treasure Island in the summer of 1944 has not been detern

It was found that a large percentage of men who had recently completed recruit training were carriers of hemolytic streptococcus and that their equipment was heavily contaminated with this bacterium.

Prior to the use of mass chemoprophylaxis, sulfonamide sensitive streptococci were spread by Farragut transfers. Following the use of mass chemoprophylaxis, Farragut Naval Training Center became the first focal point from which sulfonamide resistant strains of hemolytic streptococcus were disseminated.

There had been an outbreak of scarlet fever in January and February 1944, in the Eye, Ear, Nose and Throat ward of the Treasure Island Naval Hospital. Two corpsmen who were considered potentially "dangerous carriers" had tonsillectomies and coincident with this the outbreak subsided The incidence of scarlet fever at this Activity remained moderately high during the winter months, subsided in the spring, and almost no cases occurred in the summer.

Serologic identification of 245 cultures of hemolytic streptococcus isolated from patients with scarlet fever, acute tonsillitis, pharyngitis and rheumatic fever showed that type 19 was the predominant type during the first seven months of the year 1944. Of 60 cases of scarlet fever 46% were caused by type 19 and 40% by type 17. Scarlet fever did not occur following a relatively small group of infections caused by types 1, 6, 12, 13, 26 and 36.

During the winter and spring months of 1944, an investigation was made to determine whether streptococcal infections were being introduced in Treasure Island from Farragut, Idaho. The serologic types of hemolytic streptococcus found in the throats of patients at Treasure Island were the same as the types prevalent at Farragut. Furthermore, in one study of 18 Farragut men who had scarlet fever or tonsillitis on or shortly after arriving in San Francisco, it was found that type 19 caused 61% and type 17, 22% of these infections. Whereas, in 68 comparable patients arrival from other stations, more than half were due to nine other serologic types of organisms A statistical analysis between these two groups of men indicated that there was a significant relation between a positive culture for type 19 and recent residence in Farragut, Idaho It appeared that Farragut men were introducing type 19 and perhaps type 17 strains into Treasure Island

The origin of the Re strains at Treasure Island has not been determined. There are at least two possible explanations: (1) They may well have been among the infections introduced by Farragut men, (2) they may possibly have arisen at Treasure Island and preceded the appearance of resistant strains at Farragut. Conclusive information is not available because the testing of sulfonamide resistance was not done until the fall of 1944. However, it seems probable that Re strains appeared first at Farragut and were spread to Treasure Island by incoming drafts of men who had completed recruit training at Farragut.

SUMMARY

Streptococcal infections were transmitted from one Naval Activity to another by drafts of men from the Outgoing Units of Recruit Training Centers.

resistant The patients infected with these Re strains were born in the sulfonamide era and had had contacts with many persons who had received sulfonamide therapeutically. Their infections were caused by Re strains of types 17, 19 and 3 It was not possible in this study to determine whether Re variants of these types occur spontaneously. This information can be obtained only in isolated communities where sulfonamides have not been used

2. *Do all types of Group A hemolytic streptococcus have Re strains?* Observations were made in vivo and in vitro on several thousand cultures. Prior to the spring months of 1945 all Re strains were of types 19, 17 and 3. A few Re strains of type 6 were identified in 1945 Severe streptococcal epidemics during the war years were caused also by types 1, 5, 12, 24 and 30. Nevertheless, all strains of all types, except types 19, 17, 3 and in one camp 6, remained sulfonamide sensitive.

3. *Is sulfonamide resistance a fixed characteristic of Group A hemolytic streptococcus?* This capacity of the microorganism was tested in the infected host, the human carrier, the person receiving prophylactic or therapeutic doses of sulfonamide, in animal passage and in laboratory handling over a period of several months The sulfonamide resistance of each strain tested remained constant.

4 *Is Group A streptococcal resistance common to all sulfonamides?* Re strains were resistant to all sulfonamides whose action was reversed by para-amino benzoic acid Re strains were not resistant to "Marfanil" and other bacteriostatic drugs whose action was not reversed by para-amino benzoic acid.

5. *Is resistance related to any other characteristic of Group A hemolytic streptococcus?* The Re strains which were observed at Farragut were of types 19, 17 and 3 Irrespective of resistance, these types showed great communicability at Farragut Types 19 and 17 produced strong erythrogenic toxins The Re strains of type 6 at Bainbridge were not highly com- [illegible]

6 *Does continuous chemoprophylaxis induce resistance to sulfonamides?* [illegible]

with the exception of strains from the Training Centers at Farragut and Treasure Island Chemoprophylaxis had been administered to personnel at Farragut but not to personnel at Treasure Island. The first indication that sulfonamide resistance may have been induced by chemoprophylaxis was at Farragut However, there were also clinical indications that Re

CHAPTER VI

THE INTRODUCTION OF MASS CHEMOPROPHYLAXIS

ITS RELATION TO THE EPIDEMIOLOGY OF STREPTOCOCCUS HEMOLYTICUS

Published reports (16) have indicated the effectiveness of mass chemoprophylaxis in the Navy during the winter and spring months of 1943–44, and the loss of effectiveness at Farragut during the summer months of 1944 (17) and at the Pre-Radio Schools in Chicago during the winter months of 1945 (18). This loss of effectiveness[1] resulted from the appearance and spread of sulfonamide resistant strains of types 19, 17, and 3 Re strains, indistinguishable from those observed first at Farragut, appeared at many Naval Activities during the winter months of 1945. In their absence, chemoprophylaxis was effective. As soon as they became prevalent at a station, chemoprophylaxis lost its effectiveness. There was a fair correlation between the clinical effectiveness of prophylaxis and the in vitro sensitivity of prevalent streptococcal strains to sulfadiazine.

A. PROBLEMS IN CHEMOPROPHYLAXIS

Prior to World War II little was known about the resistance of Group A hemolytic streptococcus to sulfonamides. The sulfonamides were highly effective therapeutic agents in non-suppurative infections of man. The bacteriostatic action of these drugs was inhibited by para-amino benzoic acid, by certain amino acids and by unidentified constituents of gelatin and casein hydrolysates. The demonstration in the summer of 1944 that some strains of hemolytic streptococcus were sulfonamide resistant both in vivo and in vitro emphasized the lack of pertinent information and introduced a number of questions. The following observations have been made on some these questions·

1. *Do Re strains of Group A hemolytic streptococcus occur spontaneously?* Forty-five cultures collected in the pre-sulfonamide era were supplied by Dr. Rebecca Lancefield. In this collection there were 15 strains of types 19, 17 and 3 Irrespective of type, all cultures in this small group were sulfonamide sensitive. In 1945, 33 cultures from a civilian group with scarlet fever were tested. Forty-five per cent of these strains were sulfonamide

[1] The scarlet fever morbidity rate which rose from 1.6 in 1942 to 6 7 in 1943 fell in 1944 to 5.1 but rose again in 1945 to 7 4

(a) Memphis—Cultures were made prior to, during and following the administration of sulfadiazine. Nine of twenty patients studied were infected with type 17 Re 125, the remainder were infected with sulfonamide sensitive strains of types 19, 6, 1 and 12 There were five cross-infections in these twenty patients. The in vitro resistance or sensitivity of these strains to sulfadiazine remained unchanged

(b) Norman—A group of 21 patients was handled in the same manner as at Memphis Eleven of these patients had infections with type 17 Re 125, type 17 Re 25, type 19 Re 1 and type 19 Re 5 The remainder were infected with sulfonamide sensitive strains of types 19, 6, 24 and uncommon types. There were seven cross-infections in this group The resistance and sensitivity of these strains to sulfadiazine remained unchanged with the possible exception of one strain This organism was classified on the first culture as type 17 Re 25 and on the final culture as type 17 Re 125 This may well have been due to an error in testing

(c) Scarlet Fever Wards of a civilian hospital—A group of 30 patients was studied in the same manner as at Norman and Memphis Twelve of these patients had infections with type 19 Re 25, type 17 Re 25 and type 17 Re 125 The remainder were infected with sensitive strains of types 1, 3, 17, 19 and uncommon types There were six cross-infections in this group The resistance or sensitivity of these strains to sulfadiazine remained unchanged with two possible exceptions A type 19 strain was classified as Re 25 on the admission culture and type 19 sensitive on the final culture These may have been two distinct organisms A type 17 strain was classified as Re 25 on the first culture and Re 125 on the final culture This difference may well have been due to the limitations of the method used for testing sulfonamide resistance

In summary, both the sensitive and resistant strains of the types of hemolytic streptococcus which infected these three groups of patients appeared to be unaltered by sulfadiazine therapy. The few exceptions noted were within the range of experimental error

8 *Does prolonged contact with a blood level of 1 mg. % of sulfadiazine in man increase the resistance of Re strains showing a low resistance level?* Observations on this point were limited At most Naval Activities more than one Re strain was prevalent There were, however, several instances in which the constancy of the resistance of a strain to sulfadiazine was observed over a period of months For example, type 19 at Sampson and type 3 at some of the Great Lakes camps remained of low resistance during three months of chemoprophylaxis So far as could be determined the resistance of these strains was not increased by chemoprophylaxis

9 *Does low in vitro resistance indicate in vivo resistance?* The findings at Sampson and other Centers showed that strains resistant in vitro to 1 mg %

strains may have been present at Farragut when chemoprophylaxis was introduced. The most suggestive indication that sulfonamide resistance may have been induced by chemoprophylaxis was at Bainbridge. The personnel at this Center had received chemoprophylaxis throughout two winter and spring seasons. Late in the second season a few cultures of type 6 Re 125 were obtained from healthy carriers and patients with acute throat infections. The first of these organisms was cultured from a recruit shortly after his arrival at Bainbridge from civil life. Its appearance was observed among a group of men receiving chemoprophylaxis and at a Center where sulfonamide sensitive strains of type 6 had been prevalent. It was not possible to determine whether this strain was introduced from without or occurred by mutation

In January 1945, a severe streptococcal epidemic was caused by type 17 Re 25 at the San Diego Naval Training Center. No chemoprophylaxis had been used at this Center prior to the onset of this epidemic. Chemoprophylaxis had been used at Norman NATTC during the spring months of 1944 and six months later all throat strains of hemolytic streptococcus were shown to be sulfonamide sensitive. Nevertheless, a streptococcal epidemic in the winter of 1945 was initiated and sustained by Re strains of types 19, 17 and 3. No personnel at Norman were receiving chemoprophylaxis A streptococcal epidemic also occurred in the winter of 1945 at Memphis NATTC. This outbreak of type 17 Re 125 infections occurred among radio men but did not involve the recruits. At this time half of the recruits were receiving chemoprophylaxis. Streptococcal epidemics of Re infections at other Centers began in the Service Schools where none of the men received chemoprophylaxis. The occurrence of infections with Re strains of types 19, 17 and 3 at these Naval Activities in 1945 seemed to be associated with the introduction of these strains by carriers and to be independent of chemoprophylaxis

In summary, it was not possible to determine from the available evidence whether streptococcal resistance to sulfonamide can be induced in man by chemoprophylaxis Attempts to induce sulfonamide resistance in strains of hemolytic streptococcus in vitro were unsuccessful.

7. *Does chemotherapy induce resistance to sulfonamides?* Three studies were made to collect information on this point Groups of scarlet fever patients were selected from hospital wards prior to the administration of any sulfonamide An initial throat culture was typed and tested for sulfonamide resistance The patients were then given therapeutic doses of sulfadiazine for a period of five to ten days. Serial cultures were taken from the naso-pharynx during three weeks of hospitalization and cultures were made subsequently if suppurative complications developed The findings were.

throughout the station, the underlying conditions which had made possible the epidemic process had *not* been materially modified, there was good reason to believe that the continuous passage of Farragut strains from man to man was making these pathogens progressively more infective, the possibility that some strains of Group A hemolytic streptococcus were not susceptible to chemoprophylaxis seemed real In June, Commander Armine T Wilson was ordered from Bethesda to Farragut to

TABLE 1

Increase in Percentage of Type 19 Hemolytic Streptococcus

Type	Dec 24	Feb 15	Feb 24	Mar 15	Mar 29	Apr 27	Series D*	Series D†
19	17 6	28.3	18 1	21 2	20 5	32 2	92 8	88 0

* Special Study Camp Hill only 1st and 2nd weeks April
† Special Study random sample all Camps Last 2 weeks April

TABLE 2

Comparison of Total Treated and Untreated Groups in All Areas

	No Sulfa		0 5 Gm Sulfa		
Man Exposure Weeks	37854		39969		
	Cases	Rate	Cases	Rate	Reduction Per cent*
Catarrhal Fever	231	6 14	207	5 18	−15
Other URI	13	34	9	22	−35
Sinusitis	13	34	9	22	−35
Otitis Media	46	1 22	34	85	−15
Other Suppurative	6	16	5	12	−25
Pharyngitis	62	1 64	53	1 33	−19
Tonsillitis	41	1 08	37	92	−15
Scarlet Fever	79	2 08	80	2 00	−4
Pneumonia	23	61	20	50	−18
Rheumatic Fever	25	66	16	40	−39
Total	539	14 23	470	10 76	−25

* %Reduction in Rate equals $\frac{\text{Absolute Reduction in Rates} \times 100}{\text{Rate in Control}}$

determine whether he could identify any sulfonamide resistant strains with the method which he was then *perfecting*

Three sets of data collected during this period were illuminating (1) Cultures obt [illegible]

of sulfadiazine were also resistant in vivo to a blood level of 1 mg. %. It was not possible to collect reliable observations on whether these strains were sensitive to therapeutic blood levels.

B. OBSERVATIONS ON EPIDEMIOLOGIC CONDITIONS UNDERLYING THE FIRST APPEARANCE OF SULFONAMIDE RESISTANT STRAINS OF HEMOLYTIC STREPTOCOCCUS

The cumulative evidence collected at Naval Activities throughout the United States did not show whether chemoprophylaxis or chemotherapy induced the appearance of Rc strains of hemolytic streptococcus It was shown, however, that these strains were first recognized at Farragut Naval Training Center after the introduction of chemoprophylaxis. How long they had been present at Farragut; whether they were introduced originally by civilians entering recruit training; whether they were streptococcal variants occurring spontaneously or induced by factors yet undiscovered—the answer to these questions remains unknown. That unusual conditions, which may have facilitated the development of streptococcal variants, did exist at Farragut was pointed out in Chapter IV.

C. OBSERVATIONS MADE BETWEEN DECEMBER, 1943 AND DECEMBER, 1944 ON THE RELATION OF CHEMOPROPHYLAXIS TO MORBIDITY RATES FOR *STREPTOCOCCAL THROAT INFECTIONS AT FARRAGUT, IDAHO*

Observations on the development of Farragut as a focal point of streptococcal infections were described in Chapter IV. These phases of the epidemic occurred prior to chemoprophylaxis. Subsequent phases were:

Phase 4: In December 1943, a study of the effectiveness of chemoprophylaxis was initiated among 10,000 recruits in two Farragut camps By February 1944, the seriousness of the streptococcal epidemic demanded that the study be terminated and that sulfadiazine prophylaxis be extended to all recruit camps. In March continuous prophylaxis was administered to all enlisted personnel Overcrowding at Farragut was most severe The turnover of recruits at this time was most rapid. Virus infections were prevalent during the first half of 1944 Nevertheless, following the institution of chemoprophylaxis to all hands, the dangerous outbreak of primary streptococcal pneumonia was controlled, the transmission of streptococcal infections to other Training Centers was temporarily checked, the incidence of streptococcal diseases declined but not to so low a level as was reached at other Centers using mass chemoprophylaxis

In April there occurred a moderate exacerbation of respiratory tract infections mainly due to pneumococcus type 5 and to hemolytic streptococcus type 19 Both of these bacteria were subsequently found to be resistant to sulfadiazine in vitro

[illegible]

1 Strains obtained by Commander Wilson during his visit to Farragut in June 1944

a Type 19—40 of 42 strains examined were sulfadiazine resistant

b Type 17—12 of 12 strains examined were sulfadiazine resistant

c Other types—2 of 18 strains examined were sulfadiazine resistant

2 [illegible]

3 [illegible] few exceptions

These findings explained the clinical observations that chemoprophylaxis was ineffective during June and July Furthermore, since more than 90% of the August infections in Camps Waldron and Peterson were caused by types 19 and 17 and since nearly all strains of these types were resistant in vitro to maximal concentrations of sulfadiazine (125 mg %) there was good reason to believe that no prophylactic dosage of sulfadiazine would have proved effective These in vitro observations were confirmed in the three weeks' clinical study made between September 17 and October 8

Phase 8 No chemoprophylaxis was administered between October 8 and November 12, 1944 It had become evident in late September that chemoprophylaxis was no longer applicable to the Farragut streptococcal problem and this fact was firmly established by October 8 It had long been recognized that the most important factor in limiting the effectiveness of chemoprophylaxis might be the resistance of the respiratory pathogens to 1 mg per cent of sulfadiazine in the secretions of the upper respiratory tract At Farragut, this possibility had become a reality The potential value of chemoprophylaxis had been overtaxed Epidemic strains of hemolytic streptococcus resistant to chemoprophylaxis had become widely disseminated and they persisted at Farragut throughout the remainder of World War II

Briefly, the resistance of Farragut strains of hemolytic streptococcus to sulfadiazine in 1943 and during the winter of 1944 was not determined because the techniques necessary to make these determinations had not yet been developed For this reason it remains impossible to trace the stages in the development of sulfonamide resistant streptococci at Farragut It can be stated, however, that

(a) The passage of hemolytic streptococcus through more than one hundred thousand men within a period of eighteen months could be expected to produce variants of the bacterium

(b) The application of chemoprophylaxis tended to eliminate susceptible strains of hemolytic streptococcus

(c) The continuation of environmental conditions favorable to the spread of streptococcal infections facilitated the passage of surviving strains of hemolytic streptococcus

(d) The presence of highly infective, sulfonamide resistant strains under conditions favorable to progressive dissemination of the bacterium and in an environment where no loss of pathogenicity occurred during the summer months permitted the development of a streptococcal epidemic not amenable to chemoprophylaxis

(e) *This possibility envisaged* prior to the institution of chemoprophylaxis became an actuality at Farragut and eliminated its usefulness as a measure for preventing the implantation of hemolytic streptococcus in the respiratory tract

A hemolytic streptococcus. One of these was type 17; the other 28 cultures were type 19 The barracks that quartered recruits who had been on the station for over four weeks were the most heavily seeded This is shown in Table 3. Throughout this period of six weeks the morbidity rate for streptococcal infections was maintained at the plateau level of June 1, 1944 Chemoprophylaxis was discontinued in all recruit camps on July 23

In summary, the findings indicated that type 19 hemolytic streptococcus was at this time responsible for most infections, that the prevalent strains of type 19 were resistant to a daily half gram dosage of sulfadiazine, and finally, that perhaps contaminated floor dust in the barracks was a factor in the spread of streptococcal infections at Farragut.

TABLE 3

Bacterial Counts in Dust in Barracks

Length of Time Company in Barracks	Number of Samples	Mean Total Bacterial Count	Mean Beta Hemolytic Streptococcus Count
First four weeks in camp	20	3,720,000	2,694
Second four weeks in camp	18	5,143,070	108,631

TABLE 4

Streptococcal Throat Infections—1944

(Scarlet Fever, Tonsillitis Acute and Pharyngitis Acute)

Morbidity Rates (Annual Admission Rates per 1,000 Strength)

	June	July	Aug	Sept	Oct	Average for 5 Mos
All Navy Continental	0 8	0 7	0 7	0.8	0 8	0 8
N T C All Others	3 4	4.0	3 0	5.1	6.8	4 3
Farragut N T C	00 9	14 9	17 7	46 5	52 4	28 8
Farragut Service Schools	1 4	5.6	5 0	5 6	6.5	5 2
Farragut Station Personnel	0 1	0 5	0 4	1 3	2 7	1 2

Phase 6 During the latter half of July 1944 the streptococcal epidemic process began to change from an endemic to an epidemic state This became manifest in the week ending August 6 when the morbidity rate for scarlet fever rose to 67 The upward trend was confirmed the following week when the rate rose to 90 For the next three months the epidemic curve rose progressively As in 1943, this "contra-seasonal" change began in the middle of the summer The onset appeared a few weeks earlier and the rise was steeper but otherwise the change in the epidemic process was comparable to 1943 This change, while most striking in recruit camps, [illegible] Table 4, was also observed in the Service Schools of Farragut, but was *not*

D OBSERVATIONS ON THE RELATION OF CHEMOPROPHYLAXIS TO STREPTOCOCCAL MORBIDITY CURVES AT OTHER NAVAL ACTIVITIES DURING 1944–45

Streptococcal outbreaks occurred at several Naval Activities following the introduction of Re strains during the winter months. The morbidity

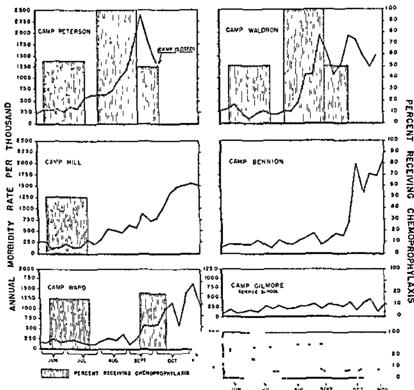


FIG 1 Morbidity Curves for Scarlet Fever, Acute Pharyngitis and Acute Tonsillitis with and without Chemoprophylaxis The epidemic infections were caused by Re strains

curves for streptococcal infections appeared to be independent of the use of chemoprophylaxis. The following examples are illustrative·

(1) Great Lakes Naval Training Center· Chemoprophylaxis was instituted on October 19 in some camps and on November 21 in other camps It was discontinued on February 1. The pattern of streptococcal outbreaks in the camps of this Center varied a great deal:

(a) In Camps Moffett and McDonough there was a sharp rise in strepto-

The observations on chemoprophylaxis made during the summer and fall months of 1944 showed that:

1. Between June 12 and July 23 there were approximately 40,000 man-exposure weeks to sulfadiazine in four recruit camps (Scott, Waldron, Hill and Ward). Chemoprophylaxis was strikingly ineffective in preventing streptococcal infections. This was explained by the demonstration that the prevalent strains of this bacterium were sulfadiazine resistant in vitro.

2. During the middle of July the Center's respiratory Sick Call rate began to climb. This was striking by August 6 in all camps except Ward. Most of these infections were mild and presumably of viral causation.

3. During the last week of July or the first week of August a streptococcal epidemic process manifested itself in three recruit camps (Peterson, Waldron and Hill).

4. *During the third week of August and the second week of September an epidemic process manifested itself in two other recruit camps* (Bennion and Ward).

5. The institution of chemoprophylaxis at Peterson and Waldron during August, and at Ward during September, occurred after the upward swing of the epidemic process was in progress.

6. Irrespective of chemoprophylaxis both camps with seasoned personnel had relatively low morbidity rates in October—Outgoing Unit, 200; Service School, 300 The lowest rates on the station occurred in Outgoing Unit during the four months of chemoprophylaxis.

7. Irrespective of chemoprophylaxis, all recruit camps had morbidity rates below 250 in June and July, above 250 either in August (Peterson, Waldron, Hill and Bennion) or in September (Ward).

8. *Irrespective of chemoprophylaxis, all recruit camps had morbidity rates over 1000 in October*

9. Irrespective of prophylaxis, morbidity levels reached a peak during November in recruit camps Ward, Bennion and Hill.

10. Irrespective of prophylaxis the epidemic curve for each recruit camp climbed to a peak in approximately eight to fourteen weeks (Peterson 8, Ward 9, Waldron 10, Bennion 13, Hill 14).

11. Irrespective of prophylaxis the peak morbidity rate for each recruit camp was between 1500 and 2400 (Hill, 1500; Ward, 1700; Waldron, 1900; Bennion, 2100, Peterson, 2400).

12. The most striking increase in morbidity rates occurred in Camp Peterson following the transfer of recruits from Camp Scott, and in Camp Bennion following the transfer of recruits from Camp Peterson

13. These findings are illustrated in Figure 1

appeared to be associated with the introduction of epidemic strains. Some of these streptococcal strains were sensitive and others were resistant to

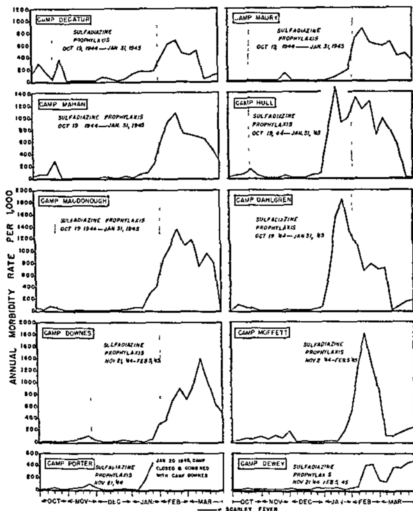


FIG 2 Morbidity Curves for Scarlet Fever with and without Chemoprophylaxis The epidemic infections were caused by Re strains

sulfonamide The introduction of chemoprophylaxis checked epidemics caused by sulfonamide sensitive strains but had no effect on the morbidity

coccal morbidity rates during chemoprophylaxis. When chemoprophylaxis was discontinued the rate fell precipitously in Camp Moffett and slowly in Camp McDonough.

(b) In Camps Dahlgren and Hull, the streptococcal rates fell precipitously during the last two weeks of chemoprophylaxis.

(c) In Camps Decatur, Mahan, Downes, Dewey and Maury, the rates began to rise during the last two weeks of chemoprophylaxis and continued upward for six weeks or longer after chemoprophylaxis was discontinued.

(d) In Camp Robert Smalls the rates remained low throughout chemoprophylaxis.

These findings are illustrated in figure 2.

(2) Sampson Naval Training Center: The variations in the morbidity curves at three recruit camps which received chemoprophylaxis from January to May were comparable to those at Great Lakes This is illustrated in figure 3.

(3) Bainbridge Naval Training Center: The Service School men received no chemoprophylaxis but all recruits were given chemoprophylaxis from January 1 to April 1 at this Center. Streptococcal epidemics occurred in both groups of men They began in the Service Schools and extended to Recruit Regiments. The morbidity rates reached a peak early in February and then fell precipitously The similarity of the morbidity curves for the two groups is seen in Figure 4 Comparable epidemics occurred in both the Service School group and the Recruit group of this Training Center. The percentage of Re strains in the throat flora was higher in the recruit regiments where chemoprophylaxis was administered than in the Service School regiment which did not receive chemoprophylaxis.

(4) Memphis NATTC: Chemoprophylaxis was administered for ten weeks of January, February, and March because of an outbreak of scarlet fever among the recruits Chemoprophylaxis was given to all personnel in the recruit barracks and to alternate barracks occupied by seasoned personnel. The effectiveness of chemoprophylaxis was lost in the latter group when type 17 Re 125 appeared among the radio men. This loss of effectiveness did not occur among the recruits, all of whom received chemoprophylaxis and all of whom escaped infections with the epidemic Re strains.

(5) San Diego Naval Training Center: A type 17 Re 25 epidemic began in one camp of this Center among recruits who had not received chemoprophylaxis. During the second week chemoprophylaxis was tested for ten

streptococcal infections recorded was higher in the group receiving chemoprophylaxis than in the control group.

Chemoprophylaxis was not administered to alternate men of a barrack in the Farragut study. However, at the Pre-Radio Schools of Chicago (18),

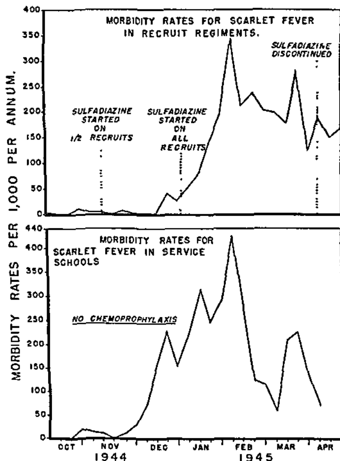


FIG 4 Morbidity Curves at Bainbridge N T C for Scarlet Fever with and without Chemoprophylaxis Epidemic infections were caused by Re strains

alternate companies of men received chemoprophylaxis before and during a period when Re strains became prevalent at these schools in Chicago. At each school, these men entered on the same day, attended the same classes and were barracked together in one gymnasium. The exposure to strepto-

curves of epidemics caused by Re strains. The transmission of Re strains appeared to be the determining factor in these outbreaks.

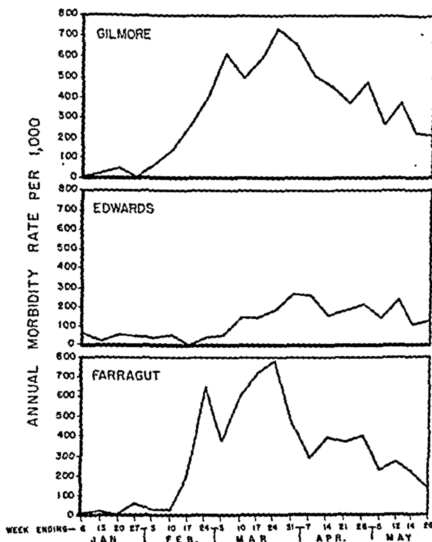


FIG 3 Morbidity Curves for Scarlet Fever during Chemoprophylaxis
The epidemic infections were caused by Re strains

E. OBSERVATIONS AT FARRAGUT ON A POSSIBLE AGGRAVATING EFFECT OF CHEMOPROPHYLAXIS IN EPIDEMICS CAUSED BY RE STRAINS

This possibility was suggested (17) by a three weeks' study made at Farragut, Idaho. Under the conditions of this study, the incidence of

chemoprophylaxis had exerted an untoward effect during the period of study. All of the data were subjected to statistical analysis by Lt Comdr. F. E Linder of the Statistical Division of the Bureau of Medicine and Surgery. His analysis follows:

"The problem considered is to determine if available data from Farragut Training Center show significantly higher morbidity rates from streptococcal disease (scarlet fever, pharyngitis, and tonsillitis) for groups receiving sulfadiazine prophylactically than for those not receiving it. In other words, does sulfadiazine have an untoward action?

"The statistical analysis is limited to reported data for Camps Peterson, Waldron and Ward for the period August 13 to October 8, 1944 At these camps during this period observations were made on odd and even numbered groups of companies and these data can be analyzed statistically Data comparing different camps cannot be analyzed statistically since no experimental controls existed

TABLE 7

Incidence of Group A Beta Hemolytic Streptococcus Infections at Herzl in Sulfadiazine Treated and in Control Groups—1944

	Control Group			Treated Group		
	Number of Group A Infections	Number of Men in Group	Weekly Rate per Thousand	Number of Group A Infections	Number of Men in Group	Weekly Rate per Thousand
	First Period					
Nov 15 to Nov 21	8	420	19 0	2	390	5 1
Nov 22 to Nov 28	12	417	28 8	0	338	0 0
Nov 29 to Dec 5	6	432	13 9	3	370	8 1
	Second Period					
Dec 12 to Dec 20	14	392	25 0	11	436	17 6

"Comparisons of morbidity rates for companies receiving 0 5 grams and those receiving 1 0 grams do not show that companies receiving 1 0 grams have a significantly higher rate

"Comparisons of morbidity rates for companies receiving 0 0 grams and those receiving 1 5 grams give slight, but inconclusive support to the possibility that the rates are significantly higher for companies receiving prophylaxis Data at hand do not permit a conclusive test Unfortunately, no analysis can be made to determine if some biasing extraneous factor has affected the rates of the even and odd companies Replications of the experiment would be necessary to establish a definite conclusion

"Comparisons of changes in morbidity rates when the prophylactic dose was changed from 5 0 to 0 0 in one group and from 1 0 to 1 5 in another group show contradictory results, and give no support to the possibility of an untoward action "

Statistical analyses failed to support the opinion that sulfadiazine prophylaxis increased the incidence of streptococcal diseases Nevertheless, it did

coccal infections was the same. The only recognized variable was individual susceptibility of the host. *Sulfadiazine resistant strains were prevalent* in these three schools during December. Nevertheless, in these three controlled studies the morbidity rates among the men receiving chemoprophy-

TABLE 5

Incidence of Group A Beta Hemolytic Streptococcus Infections at Wright in Sulfadiazine Treated and in Control Groups—1944

	Control Group			Treated Group		
	Number of Group A Infections	Number of Men in Group	Weekly Rate per Thousand	Number of Group A Infections	Number of Men in Group	Weekly Rate per Thousand
First Period						
Nov. 14 to Nov. 20	12	451	26.6	2	476	4 2
Nov 21 to Nov. 27	13	453	28 4	2	465	4.3
Nov. 28 to Dec. 4	14	458	30.6	1	458	2 2
Second Period						
Dec 12 to Dec. 18	15	530	28 3	4	455	8.8
Dec. 19 to Dec. 25	15	530	28 3	11	448	24 6
Dec. 26 to Jan. 2	22	530	36 4	13	452	25.2

TABLE 6

Incidence of Group A Beta Hemolytic Streptococcus Infections at Manley in Sulfadiazine Treated and in Control Groups—1944

	Control Group			Treated Group		
	Number of Group A Infections	Number of Men in Group	Weekly Rate per Thousand	Number of Group A Infections	Number of Men in Group	Weekly Rate per Thousand
First Period						
Nov. 7 to Nov 13	4	676	5 9	0	444	0 0
Nov 14 to Nov 20	6	703	8 5	0	393	0.0
Second Period						
Nov. 28 to Dec 4	15	611	24 5	1	575	1 7
Dec 5 to Dec 11	17	603	28.2	3	555	5 4
Dec. 12 to Dec 20	19	510	28 9	13	512	19.7

laxis remained lower than those not receiving chemoprophylaxis. These findings are presented in Table 5, 6 and 7, *taken from the report by Damrosch (18).*

A further analysis was made of the Farragut study to determine whether

chemoprophylaxis had exerted an untoward effect during the period of study. All of the data were subjected to statistical analysis by Lt Comdr. F. E. Linder of the Statistical Division of the Bureau of Medicine and Surgery His analysis follows:

"The problem considered is to determine if available data from Farragut Training Center show significantly higher morbidity rates from streptococcal disease (scarlet fever, pharyngitis, and tonsillitis) for groups receiving sulfadiazine prophylactically than for those not receiving it In other words, does sulfadiazine have an untoward action?

"The statistical analysis is limited to reported data for Camps Peterson, Waldron and Ward for the period August 13 to October 8, 1944 At these camps during this period observations were made on odd and even numbered groups of companies and these data can be analyzed statistically Data comparing different camps cannot be analyzed statistically since no experimental controls existed

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Statistical analyses failed to support the opinion that sulfadiazine prophylaxis increased the incidence of streptococcal diseases Nevertheless, it did

appear at Farragut NTC and at Memphis NATTC that for a period of several weeks the incidence of scarlet fever was higher among the men receiving chemoprophylaxis than among the controls. In each instance these infections were caused by Re strains of type 17. However, at the Chicago Pre-Radio Schools, where chemoprophylaxis was administered to alternate men sleeping in the same quarters, type 17 Re strains spread through the entire population. Under these conditions the incidence of infections with Re strains was moderately higher among the controls than among those receiving chemoprophylaxis. Furthermore, at San Diego N.T.C. a type 17 Re 25 epidemic began among recruits none of whom had received chemoprophylaxis. In contrast, at Bainbridge N.T.C. where all recruits received chemoprophylaxis, type 6 Re 125 infections occurred during the spring months without causing a streptococcal outbreak. These findings indicate that the critical factor in determining whether an outbreak occurred was the capacity of certain strains of hemolytic streptococcus to spread rapidly. Once introduced, these resistant strains gave rise to explosive outbreaks irrespective of whether the subjects were receiving prophylaxis.

SUMMARY

Prior to September 1944, streptococcal outbreaks among Navy personnel were caused by sulfonamide sensitive organisms of many types. Subsequently they were caused chiefly by sulfonamide resistant strains of types 17, 19 and 3. This change occurred during the use of mass chemoprophylaxis. At some stations it appeared that the use of this preventive medicine measure may have exerted a selective action on the prevalent strains of hemolytic streptococcus. Certainly, the passage of sulfonamide resistant strains was not inhibited by chemoprophylaxis The application of chemoprophylaxis has been evaluated in a recent review by Wilson (19).

At Farragut Naval Training Center, these strains were both highly communicable and pathogenic for man. At other Centers, they either had not been present or were of such low infectivity that they failed to be of practical importance. However, in 1945 streptococcal outbreaks occurring throughout the Navy were caused chiefly by strains indistinguishable from those which had been identified at Farragut. The introduction of highly communicable, pathogenic, Re strains of types 17, 19 and 3 into Naval Activities counteracted the effectiveness of chemoprophylaxis as a streptococcal control measure. This occurred irrespective of whether chemoprophylaxis was administered continuously or only for a ten day period or was not administered. It was evident that the application of a bacteriostatic agent as a control measure is limited to the extent that sulfonamide sensitive organisms prevail.

The genesis of sulfonamide resistance in Group A hemolytic streptococcus

remained undetermined. In the U. S. Navy, this characteristic was limited to types 17, 19 and 3, with the exceptions of type 6 at Bainbridge and several sporadic infections caused by Re 1 or Re 5 strains of types 5, 1 and 24. It seemed to be a fixed characteristic, apparently unrelated to other characteristics of the bacterial cell. All attempts to induce or modify sulfonamide resistance of Group A hemolytic streptococcus were unsuccessful. One study at Farragut suggested that the use of sulfonamide prophylaxis in the presence of Re strains exerted an untoward effect However, a statistical analysis of this study was not in accord with this observation and the findings at other Naval Activities were not confirmatory.

These experiences in the use of mass chemoprophylaxis indicate the great need for knowledge of the mechanism of bacterial resistance to bacteriostatic agents but supply no information on this point The solution of this key problem must await more fundamental work on the genetics and the metabolism of the streptococcal cell.

CHAPTER VII

THE SPREAD OF SULFONAMIDE RESISTANT STRAINS OF STREPTOCOCCUS HEMOLYTICUS TO NAVAL ACTIVITIES IN THE MIDWEST

Streptococcal morbidity rates rose sharply in October, 1944 among Naval personnel receiving training in or near Chicago. In November, outbreaks of scarlet fever, pharyngitis and tonsillitis occurred at several Activities which had been almost free of these infections during the summer months. It was believed that the causative agents were sulfonamide sensitive. This opinion was confirmed in the laboratory at Bethesda where the strains of hemolytic streptococcus cultured from the throats of Naval personnel in Chicago were all found to be sulfonamide sensitive in vitro irrespective of serologic type. In December, 1944, the appearance of strains of hemolytic streptococcus, resistant in vivo to sulfonamide prophylaxis was recognized at Naval Radio Schools in Chicago. This clinical observation was confirmed by in vitro tests, and these sulfonamide resistant organisms were shown to be strains of types 19, 17 and 3

Observations were made between October, 1944 and July, 1945 at seven Naval Activities and one civilian group in Chicago. Three of these Activities, the Pre-Radio Schools, were similar in that: (1) there was a turnover of their trainees every 25 days, (2) their men came directly from Recruit Training Centers, (3) their personnel lived under comparable conditions, and (4) their training schedules were alike. It was in these three schools that Re strains of hemolytic streptococcus were first observed in the Midwest

A. EARLY OBSERVATIONS

Description of Pre-Radio Schools A published Navy report has described in detail the environmental conditions present at the three Pre-Radio Schools in Chicago (18). In that report, Wright Junior College was called School Red; Hugh Manley School was called School White, Theodore Herzl School was called School Blue The three school buildings before occupation by the Navy had been parts of the school system of Chicago Architecturally, they were quite similar, all being three-storied brick or stone buildings They contained classrooms for 40 or 48 students each, an auditorium, a gymnasium, offices and a cafeteria School Blue had a single gymnasium [illegible] Schools Red and White had two gymnasiums and a swimming

minimal structural changes The gymnasiums and some of the classrooms were used as berthing facilities The remaining classrooms retained their original function Additional toilet facilities were installed A dispensary and one or two wards were also installed in each These were staffed by a medical officer and hospital corpsmen The wards were used for the care of throat infections, minor illnesses and injuries Patients with scarlet fever and more serious or prolonged illnesses were transferred to the Great Lakes Naval Hospital

The pressing demands of the war-time Navy Training Program made necessary a certain amount of compromise with accepted hygienic standards at a number of Navy Activities This was especially true at the Pre-Radio Schools in Chicago The urgent need for radiomen and the limited space available for berthing led to crowded sleeping arrangements in each school Triple decked bunks were employed throughout At School Red 400 men were housed in each of the two gymnasiums, which contained in each instance 6,000 square feet of floor area and 168,000 cubic feet of volume The smaller bunk rooms housed from 51 to 69 men and contained 720 to 960 square feet of floor area and 10,080 to 13,440 cubic feet of volume respectively At School White the two gymnasiums berthed 420 men each and the measurements of each were 5,975 square feet and 155,350 cubic feet The smaller bunk rooms berthed 30 to 75 men, and their measurements ranged from 735 to 1,795 square feet and 9,552 to 23,335 cubic feet respectively At School Blue 240 men slept in the gymnasium which contained 4,500 square feet and 90,000 cubic feet, 36 to 60 men slept in the smaller bunk rooms which contained 750 to 1,500 square feet and 11,250 to 22,500 cubic feet The space between bunks varied somewhat but was rarely in excess of 4 feet In many rooms the bunks were arranged in blocks of six (i e two triple decked bunk sections) with no space between sections The men were required to sleep head to foot throughout

During the training period of three and one-half weeks the men received intensive didactic work which necessitated much study and relatively little time outdoors Liberty was granted one evening each week and from Saturday noon until Sunday night At these times the trainees were free to engage in whatever recreational activities in Chicago they desired At the end of the training period, graduates were transferred to other Naval Activities and new groups of men were received During these transition periods of one week there was some mixing of outgoing and incoming groups However, the majority of outgoing men had usually departed before any substantial number of new trainees arrived There was little or no traffic between Schools Red, White, and Blue In each period a small group was held over to repeat the course These repeaters had been ill or deficient during their assigned training period A large proportion of the repeaters had been ill with streptococcal infections

1 *Observations at Wright Junior College* This Pre-Radio School with an average complement of about 1,100 men had living conditions comparable to, but perhaps better than, those at Manley and Herzl. During early November an outbreak of scarlet fever occurred among these men. The causative agents were identified as hemolytic streptococcus, types 17 and 3 sulfonamide sensitive A new class entered during the second week of November Four days later a trainee who had come from Great Lakes developed scarlet fever The causative agent was identified as type 17 Re 25 This man was removed to a hospital and the organism did not

spread. During the remainder of November the streptococcal infections were associated chiefly with types 17, and 19, but also with types 3, 6 and 44—all sulfonamide sensitive. However, during the final training week of this class there were three other infections caused by resistant organisms. Two were due to type 3 Re 5 and one to type 19 Re 5.

A new class was admitted early in December. Four days later resistant organisms began to appear in the throat flora of many patients with streptococcal infections; first, type 3 Re 5, then type 17 Re 25 and later type 3 Re 25. During the last two weeks of training the most prevalent organisms were type 17 Re 25 and type 3 Re 25. On the last day of training type 3 Re 5 was again recovered from one man with pharyngitis and another with scarlet fever.

A new class entered on January 2nd. The throat flora of the school changed. Types 24 and 12 appeared the next day They were sulfonamide sensitive. Four days later type 19 Re 25 was cultured. This type 19 Re organism became predominant during the last two weeks of this training period. The most prevalent organisms during the remainder of the winter months were type 3 Re 5 and type 17 Re 25.

In summary, these findings indicated that with each incoming class there were changes in the bacterial flora: (a) October class—almost all infections were due to sensitive organisms of type 17, (b) November class—most infections were due to susceptible organisms of type 17 and type 19; (c) December class—most infections were due to type 17 Re 25; (d) January class—most infections were due to type 19 Re 25.

It appeared in many instances that new respiratory tract pathogens were introduced by the incoming drafts In some instances they failed to spread. In others they seemed to be disseminated and to reach a peak incidence during the final week of the twenty-five-day training period It also appeared that some organisms were seeded at this Activity and gave rise to sporadic infections These findings suggested that there were two bacterial reservoirs, (a) the arriving recruit who introduced new strains, and (b) the environment seeded with organisms by an outgoing class.

The first Re organism type 17 Re 25 was recovered from a man who had been at the school only a few days. He came from Great Lakes at a time when this station appeared to have only sulfonamide sensitive organisms On arrival he came into close contact with Farragut men who had been infected with type 17 Re 25.

2. *Observations at Hugh Manley School.* This Pre-Radio School had about 1,400 men in training The incidence of streptococcal infections was low in October and early November; the causative strains were types 19, 17 and 3. All of the strains tested were sulfonamide sensitive in vitro.

A new class entered on November 4th The incidence of "catarrhal fever" increased but there was only one case of scarlet fever. The causative strain was type 19 During this twenty-five day period, 20 cultures of hemolytic streptococcus Group A were identified, seven were type 19, six type 17, six type 3, one type 6 All were sulfonamide sensitive in vitro

Another class was admitted at the end of November. Cultures taken four days later showed that the throat flora of the personnel had changed: type 30 sensitive to sulfonamide and type 3 Re 5 appeared Infections by these organisms were followed by type 19 Re 1 and type 17 Re 25 infections Before this class was graduated, strains of type 3, either Re 1 or Re 5 became the predominant organisms Re strains of types 19 and 17 did not spread

A new class was admitted in December During the second week type 17 Re 125 appeared Type 3 Re strains became progressively less common. Later type 17 Re 125 became prevalent and with subsequent classes it remained the predominant organism in the Pre-Radio School.

In summary, the origin of these type 3 Re 5 or Re 1 infections is unknown. They appeared to follow the arrival of men from Recruit Training Centers The men who first contracted these infections about five days after arrival came from Great Lakes. At this time no sulfonamide resistant organisms had been recovered from Great Lakes and type 3 Re 5 and Re 1 strains were known to exist only at Farragut, Idaho Later it appeared that other types were introduced by classes arriving in Chicago from Farragut. Type 17 Re 125 persisted

3. *Observations at Theodore Herzl School* This Pre-Radio School had a complement of about 800 men in training The incidence of streptococcal infections was low in October There were six patients with scarlet fever, pharyngitis and "catarrhal fever" The infecting strains of hemolytic streptococcus were identified as types 19 and 17 All were sulfonamide sensitive in vitro

The incidence of streptococcal infections increased during the first two weeks of November. Thirty-eight cultures were examined Sixteen were type 19, fifteen were type 17, three were type 3, four were unidentified All of these organisms were sulfonamide sensitive in vitro

A new class of transfers arrived in the middle of December Five days later the first sulfonamide resistant organisms were cultured from two patients, both type 19 Re 25 One infection was mild, it was diagnosed as "catarrhal fever" The patient was treated in the school's dispensary and returned to duty This new arrival had come from Farragut, Idaho, where type 19 Re 25 was prevalent. The other infection was diagnosed as

scarlet fever. This patient had come from Great Lakes. He was transferred to the Naval hospital. The sulfonamide sensitive organisms of 19, 17 and 3 maintained their preponderance until a new class entered.

A few days after the arrival of a class in January there was a striking change in the throat culture findings. Most of the streptococcal infections were caused by type 19 Re 25, a few infections by type 3 Re 5 and none by type 17. Throughout the remainder of the winter months over 90% of the streptococcal infections which were identified serologically were shown to be caused by type 19 Re 25.

In summary, type 17 disappeared when type 19 Re 25 organisms were introduced into this school. The Re organisms were recovered first from two men who had been at Herzl only six days. One man with scarlet fever was transferred promptly to the Great Lakes Naval Hospital. The other man with a mild upper respiratory tract infection was kept in a dispensary room at Herzl for 10 days and then returned to duty. This man may well have spread contagion. He came from Farragut, Idaho, where type 19 Re 25 organisms had been prevalent and had caused clinical manifestations similar to those which later appeared at Herzl. It seemed that the introduction of type 19 Re 25 infections into this school may have resulted from the fact that a man with a mild upper respiratory tract infection caused by hemolytic streptococcus type 19 Re 25 did not have a scarlatiniform rash and was not isolated.

4 *Summary of Observations on Three Pre-Radio Schools:*

(a) Re strains of hemolytic streptococcus were not recovered at these Pre-Radio Schools prior to November 15, 1944.

(b) Re strains appeared early in the winter following the arrival of new classes from training centers

(c) These Re strains were indistinguishable from those which had been prevalent at Farragut, Idaho, at this time. They had not been recovered at other training centers which sent men to these Pre-Radio Schools.

(d) Each of the incoming classes included Farragut drafts. These drafts of men were divided approximately equally between the three Pre-Radio Schools Throat culture studies on one draft of Farragut men showed that on arrival in Chicago 34% were carriers of hemolytic streptococcus including Re strains of types 19, 17 and 3.

(e) Throat cultures were not made routinely on all arrivals The possibility that Re strains were introduced from points other than Farragut cannot be excluded

B. LATER OBSERVATIONS IN CHICAGO

Sulfonamide resistant strains of hemolytic streptococcus were recovered in Chicago from other Naval Activities and from one civilian group during

the winter and spring months of 1945. These Naval Activities differed from the Pre-Radio Schools in many respects. Some of the differences were: the rate of turnover was slower, the barracks were less overcrowded; the life was less confining; and perhaps of most importance, the personnel was not limited to transfers from Recruit Training Centers

1. *Observations at Radio Chicago* (65 West Lake Street): This Activity supplied three months of advanced instruction to 600 graduates from training centers, principally Great Lakes and Farragut Men lived under congested conditions Even though "seasoned" by training in recruit camps and in radio schools they manifested susceptibility to streptococcal diseases On January 6, 1945, throat cultures were taken to determine what types of hemolytic streptococcus were being introduced into this Activity In fifteen cultures the following types were recovered. 1, 6, 12, 17, 19, 24, 36, as well as, type 3 Re 5, type 19 Re 25 and type 17 Re 125. This small sample reflected most of the types prevalent in the Navy at that time. During January, February and March the Re strains of types 19, 17 and 3 maintained predominance

It appeared that although many serologic types of hemolytic streptococcus were introduced into this Activity, three Re strains of types 17, 19 and 3 showed the greatest capacity to spread and persist.

2 *Observations at Navy Pier*. This station with a complement of 6,500 men gave several types of graduate training to men from many Naval Activities In November and December there was a moderate number of respiratory tract infections but no scarlet fever Identification of hemolytic streptococci in the throat flora showed that many serologic types were present In order of prevalence they were types 19, 17 and 6, with a few of type 5, 36, 1, 12, 44, 3 and uncommon types The first case of scarlet fever occurred on January 9th, the causative agent was type 17 Re 125 On January 19th, type 19 Re 25 and type 3 Re 1 were recovered from patients with pharyngitis and scarlet fever During the last week of January type 17 Re 125 began to spread rapidly. During February the incidence of streptococcal disease increased markedly These infections were caused almost entirely by type 17 Re 125

The streptococcal morbidity rates at Navy Pier in 1945 were lower than those of the Pre-Radio Schools and also much lower than its own rates for the preceding winter There had been a change in the type of training at Navy Pier The complement was reduced by about 30%, the training course was lengthened and the turnover of personnel slowed, drafts of men from recruit camps were no longer received The Navy Pier personnel in 1945 were men who had completed training in the Pre-Radio Schools. They were arranged in companies of 150 men. The older group of trainees were barracked together at considerable distance from the newer companies.

The incidence of upper respiratory tract infections was relatively low in the older companies and highest in the newly formed companies This is shown in Figure 1.

Prior to January, 1945 all streptococcal strains were sulfonamide sensitive. The first three Re strains were cultured in three Great Lakes recruits who had become ill in Chicago and were admitted to the Navy Pier Sick List for treatment. Navy Pier personnel were hospitalized in open wards

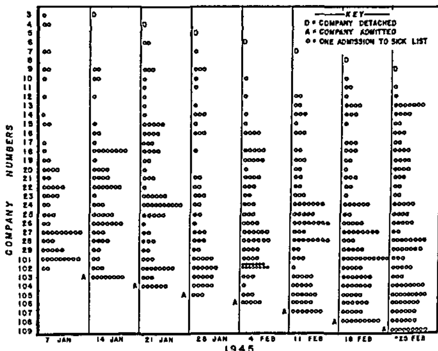


FIG 1 Relative Prevalence of Respiratory Tract Infections in Old and Newly Formed Companies at Navy Pier 1945

of the Wesley Memorial Hospital with men from Chicago's Pre-Radio Schools where Re streptococcal infections were epidemic. Furthermore the newly formed classes at Navy Pier included men who had recently recovered from Re streptococcal infections at the Pre-Radio School. The introduction of Re strains into the Navy Pier may have occurred either from the Pre-Radio School or from the Great Lakes Naval Training Center. Coincident with the introduction of these strains the incidence ... infections showed a striking increase.

... ation with a comple-

... Its personnel were

chiefly men from overseas. There was no overcrowding in 1945. No severe streptococcal outbreaks occurred. During November and December type 17 predominated Late in February organisms of type 17 Re 125 and type 19 Re 25 appeared. These organisms and type 3 Re 5 were obtained in March None of these strains spread. Their origin was not determined.

4. *Observations at NATTC, 87th and Anthony.* This Naval Aviation Technical Training School had a complement of 2,800 men. Its personnel were men with lengthy Naval Service. Housing conditions were excellent. The incidence of streptococcal infections, which had been high in previous years, remained low throughout the winter and spring months Type 3 Re 25 was cultured on January 3rd, type 17 Re 25 on March 27th, type 17 Re 125 on April 12th, type 19 Re 25 on April 18th. None of these organisms spread Their origin was not determined

5 *Observations at Midshipmen School* The men were quartered in the rooms of Abbot and Tower Halls In March four men had scarlet fever. The causative agent was type 17 Re 125. This organism was also found to be predominant among a small group of carriers. The excellent living conditions were probably a factor in its failure to spread The origin of type 17 Re 125 was undetermined. However, contact with Pre-Radio School students occurred in Wesley Hospital

6. *Observations at the Chicago Municipal Contagious Disease Hospital:* Throat cultures were taken of 33 civilian patients with scarlet fever upon arrival Nine infections were caused by type 19 Re 25, five by type 17 Re 25 and the
and uncommor
Re 25 and 17
during March 1945 So far as could be determined, these scarlet fever patients, with possibly two exceptions, had had no sulfonamide prior to their hospital admission and only three of them had had any contact with Naval personnel The finding that 42 percent of this group of infections in civilians of Chicago were caused by Re strains of hemolytic streptococcus was unexpected Possible explanations for this finding were. (1) These Re strains had been present in Chicago but unrecognized because in the past they had not been tested for sulfonamide resistance, (2) Re strains of types 19 and 17 had been disseminated by Naval personnel throughout the widely scattered population of Chicago just prior to this study.

C. OBSERVATIONS ON THE SPREAD OF HEMOLYTIC STREPTOCOCCUS TO THE GREAT LAKES NAVAL TRAINING CENTER

This was the largest Naval Training Center in the world. Situated 50 miles north of Chicago, it reached a census of over 100,000 personnel and included the following more or less independent areas:

1. Green Bay area, recruit camps
2. Downey area, recruit camps
3. Service Schools
4. Outgoing Unit
5. McIntyre Dispensary
6. Great Lakes Naval Hospital
    1. The following camps were located in the Green Bay area:
        Dahlgren—21st regiment
        Decatur—23rd regiment
        Hull—25th regiment
        McDonough—27th regiment
        Mahan—29th regiment
        Maury—31st regiment
    2. The following camps were located in the Downey area:
        Dewey—12th regiment
        Downes—10th regiment
        Lawrence—16th regiment
        Moffatt—14th regiment
        Porter—8th regiment
        Smalls—18th regiment

Streptococcal morbidity rates began to climb progressively in September, 1944 at Great Lakes During the second week of October there were 44 cases of scarlet fever among recruits in the Green Bay area, 14 cases among recruits in the Downey area and three cases in the Service schools The largest number of these came from camp Decatur in the Green Bay area and most of these cases came from four barracks. These streptococcal infections were caused by type 17 organisms which appeared to be sulfonamide sensitive in vivo Between September 1 and October 31, 1944, 326 cultures from Great Lakes patients were tested in vitro. No Re strains were detected The findings are summarized briefly in Table 1.

Table 1 shows that during the early fall months the predominant organisms in these camps were types 17 and 19 The sulfonamide resistance of a large percentage of these organisms was tested. All strains were sulfonamide sensitive until October 31st when cultures from one patient in the Service School and one in Camp Porter (Prison Camp) were found to be type 19 Re 25 At this time, so far as could be determined, it was only in the Service Schools and Camp Porter that direct contact with transfers from Farragut Naval Training Center may have occurred

During this period all recruits with tonsillitis and pharyngitis were treated in their camp dispensaries Those with scarlet fever were transferred to the McIntyre Dispensary for treatment. All cases of scarlet

fever from the Naval Activities in the Chicago area were transferred to the Great Lakes Naval Hospital prior to November 18, 1944 On this date it became necessary to accommodate war casualties For this reason, men with communicable diseases including scarlet fever patients from the Chicago Pre-Radio Schools, were transferred from the Great Lakes Naval Hospital to the McIntyre Dispensary. By December 12th all patients with communicable diseases in the Chicago area were admitted directly to the McIntyre Dispensary. There they were assigned to wards according to their diseases. The scarlet fever patients from the Pre-Radio Schools

TABLE 1

The Distribution of Hemolytic Streptococci at the Great Lakes Naval Training Center in September and October 1944

Camp	Predominant Type	Other Types	Sulfonamide Resistance
Dahlgren	17	6, 3, 1, 19, 12	0
Decatur	*17*	*6, 3*	*0*
Dewey	—	17, 19, 5	0
Downes	18	6, 3, 33, 4	—
Hull	17	19, 44, 26	0
Lawrence	—	19, 17	—
Mahan	19	3, 6, 4	0
Maury	—	19, 28, 3, 17	0
McDonough	—	Not common types	0
Moffett	17	19, 3, 24, 28	0
Porter	—	19, 24, 6	*
Smalls	19	None	0
Service Schools	19	17, 30, 3	*
Out Going Unit	17	19, 3, 26, 44, 28	0

* One culture obtained on October 31st was type 19 Re 25.

of Chicago were placed in double-decked scarlet fever wards with the recruits from the camps of the Great Lakes Naval Training Center At this time, these wards had scarlet fever patients from the Green Bay camps, Downey camps and the Service Schools.

Sulfonamide resistant strains of hemolytic streptococcus appeared among personnel of seven Great Lakes camps during November and December, 1944. In the Service Schools, hemolytic streptococcus type 17 Re 125 was active during November In most of the recruit camps type 19 Re 25 and type 3 Re 5 were first recovered in December after similar Re strains had been identified among men of the Pre-Radio Schools of Chicago The order of appearance of Re strains was as follows:

Camp	Date of Culture	Strains
Service Schools	November 3	17 Re 125
Mahan	November 26	3 Re 5
Decatur	December 4	17 Re 25
Dahlgren	December 6	17 Re 125
Maury	December 7	3 Re 5
Hull	December 12	17 Re 25
Downes	December 22	3 Re 25
McDonough	December 26	17 Re 125

The initial cultures of Re strains were obtained in seven recruit camps of the Green Bay and Downey areas shortly after the McIntyre Dispensary

TABLE 2

A Comparison between Types of Hemolytic Streptococci Causing Infections Prior to and After November First

Camp	Area	Date of Culture	Re Strains	Types Recovered in Previous 4 Weeks	
				Predominant	Present
Service Schools		November 3	17 Re 25	None	19, 30
Mahan	Green Bay	November 26	3 Re 5	19	6, 17
Decatur	Green Bay	November 27	17 Re 25	None	6, 17
Dahlgren	Green Bay	December 6	17 Re 125	None	6, 17, 5
Maury	Green Bay	December 7	3 Re 5	None	6, 17, 12
Hull	Green Bay	December 12	17 Re 25	17	19, 12, 1
Downes	Downey	December 22	3 Re 5	None	17, 18
McDonough	Green Bay	December 26	17 Re 25	None	19, 30

scarlet fever wards were seeded with scarlet fever patients from the Pre-Radio Schools of Chicago During the early weeks of 1945, Re strains appeared in all other camps except Camp Smalls. (See Chapter VI, Figure 2) This camp was situated on the northern border of the Center and had only Negro recruits Between October, 1944 and April, 1945 scarlet fever was not diagnosed in this camp For this reason, no Negro recruits were treated in the scarlet fever wards of the McIntyre Dispensary and none had contact with men from the Pre-Radio Schools of Chicago.

Discussion: There were at least three possible explanations for the appearance of sulfonamide resistant streptococci within a few weeks in the widely separated camps of the Green Bay and Downey areas.

the Re strains are given in Table 2

Table 2 shows that with the exception of Camp Hull and possibly Camps Dahlgren and Decatur the serologic types of the sulfonamide resistant organisms were different from the sulfonamide sensitive types of hemolytic streptococci which had been causing acute infections in these camps. In Camps Mahan, Maury and Downes, where type 3 Re 5 suddenly became predominant, type 3 had been conspicuously absent among men with acute infections. In Camp McDonough, where type 17 Re 25 became predominant, type 17 had been conspicuously absent among men with acute infections. Although it is possible that there were healthy, undetected carriers who harbored these Re strains, it would seem more reasonable to conclude that these Re strains did not originate from the serologic types of hemolytic streptococci prevalent in these camps.

Second, it seemed possible that the introduction of some of the Re strains into Great Lakes may have been due to contact with carriers of Re organisms. The early appearance of type 17 Re 25 in the Service Schools, where men from Farragut and other training centers were gathered, and where there was ample opportunity for contact with civilians off the station, makes this a possibility which cannot be excluded.

Third, it seemed probable that highly communicable Re strains were disseminated in the camps of Great Lakes by recruits returning from the scarlet fever wards of the McIntyre Dispensary. These wards were double-decked, without isolation facilities, and after November 18, 1944, they received Chicago Pre-Radio School patients infected with Re strains of hemolytic streptococci indistinguishable from those which subsequently appeared in the recruit camps of Great Lakes.

The incidence of cross infections in the wards of the McIntyre Dispensary was not determined. That cross infections did occur is inferred from the fact that four ward medical officers, seven internes, approximately 80 nurses and a large number of hospital corpsmen contracted streptococcal diseases while working in these wards during the winter months of 1945. Furthermore, it was later shown that patients from these wards carrying Re strains in their throat flora gave rise to return cases in their barracks after resuming training.

In summary, the findings indicate that, although some type 17 Re 25 infections in the Service Schools may have originated from contact with unrecognized carriers, the important link in the spread of Re strains of hemolytic streptococcus to the recruit camps was contact between Great Lakes recruits and Pre-Radio School men of the Scarlet Fever Wards of McIntyre Dispensary.

SUMMARY

Sulfonamide resistant strains of hemolytic streptococcus were first recognized in the Midwest at the Pre-Radio Schools of Chicago. Each

of these schools received monthly drafts of men from the Outgoing Unit of Farragut Naval Training Center. In October, 1944 this was the only Training Center in which Re strains were prevalent. Throat cultures of Farragut drafts made on arrival in Chicago showed that 31% were carriers of Group A hemolytic streptococcus Other Midwest Naval Activities which received no transfers from Farragut escaped infections with Re strains during December, 1944 and the early months of 1945

Environmental conditions at the Pre-Radio Schools appeared to facilitate the rapid passage of hemolytic streptococcus. However, streptococcal outbreaks did not occur until the fall months when climatic conditions became favorable to the spread of respiratory tract infections. At that time, some of the streptococcal outbreaks in the Pre-Radio School classes appeared to be initiated by carriers in arriving drafts, and other outbreaks appeared to be due to contamination left by graduating groups.

The Naval Training Center at Great Lakes, situated 50 miles from Chicago, escaped an outbreak of streptococcal infections with Re strains until a mingling of Great Lakes recruits and Pre-Radio School men occurred in the scarlet fever wards of McIntyre Dispensary. Following this, there was a striking change in the throat flora of Great Lakes patients with streptococcal infections Re strains indistinguishable from those originally prevalent at Farragut and later prevalent at the Pre-Radio Schools became prevalent in all camps at Great Lakes except the Negro camp In this camp, scarlet fever had not been recognized; men with streptococcal throat infections had been treated in the camp dispensary, there had been no contact between men of this camp with Pre-Radio School men and other Great Lakes recruits in the scarlet fever wards of McIntyre Dispensary

These observations indicated that Re strains of hemolytic streptococcus were spread from Farragut, Idaho, to Chicago and from Chicago to Great Lakes Later these strains were spread by drafts of men from the Great Lakes Outgoing Unit to other Naval Activities in the Midwest.

CHAPTER VIII

THE SPREAD OF SULFONAMIDE RESISTANT STRAINS OF STREPTOCOCCUS HEMOLYTICUS TO NAVAL ACTIVITIES IN THE SOUTHWEST

Attention has been drawn to the fact that Re strains of types 19 and 17 were present in the summer of 1944 at Treasure Island, California (Chapter V, page 42). The source of these strains was unknown, although it appeared that they may have been introduced by carriers from Farragut. In January, 1945, Re strains were introduced into a Naval Activity at Del Monte, California In this instance it was possible to trace the transfer of these respiratory tract pathogens from Illinois to California At that time a more severe streptococcal outbreak occurred in the San Diego Naval Training Center The origin of this epidemic was not determined The findings at these two stations are presented:

A. OBSERVATIONS AT THE NAVAL TRAINING SCHOOL, DEL MONTE, CALIFORNIA

This description deals with the observations made during the week ending January 13, 1945. It deals primarily with streptococcal infections occurring among a draft of men arriving from the Pre-Radio Schools of Chicago It also includes observations on the pre-epidemic conditions and on the infections present in drafts of men arriving at Del Monte in December, 1944

1 *Living Conditions and Personnel* The students were comfortably quartered, six to eight in a room at the Del Monte Hotel. They slept in double-decked bunks The quarters were large, well ventilated, carpeted rooms There were ample toilet and washing facilities The school messed in a large hall Each class entered the mess hall as a unit and occupied a specific part of the room The food was prepared and served under contract with the Del Monte Hotel The school day began at 0600 and the greater part was spent in classrooms and shops Liberty was granted to 900 students once weekly from Saturday at 1300 to Monday at 0600 Recreational facilities on the station included an outdoor salt water swimming pool, a large athletic field, a library, a motion picture theatre and a Ship's Service including a soda fountain.

The Ship's Company lived off the station for the most part and had its own mess hall but shared the food prepared for the students Most of the

officers lived off the station and had a separate mess. About 100 women civilian employees, waitresses, galley and laundry workers lived in dormitories provided by the hotel.

In brief, conditions in the living quarters, classrooms, shops, galley, and recreational facilities were highly satisfactory throughout this school.

The personnel at this Activity consisted of 1300 enlisted men under instruction as radio technicians, 150 enlisted Ship's Company, 21 officers and 200 civilian employees. The streptococcal diseases under investigation occurred chiefly in men under instruction. These students spent a three-month period on the station. Most of them had been in the Naval Service about six months and had completed basic training at the U. S. Naval Training Station, Great Lakes, Illinois during the summer or fall of 1944. Following this they had completed a three and a half weeks' course of instruction at the Chicago Pre-Radio schools, Hugh Manley, Wright Junior College or Herzl Junior College A few students came from the Radio School, Michigan City, Indiana. Every two weeks a class of 200 new students from these schools arrived at Del Monte to take the places of a similar number of graduating students who went on to advanced radio schools.

2. *Outbreak of German Measles:* Prior to November 11, 1944 the incidence of scarlet fever and acute tonsillitis or pharyngitis was low at this station. Only four cases of scarlet fever were diagnosed during the four-month period from May through August, 1944.

A sharp rise in the incidence of German measles began on November 6. The first four cases occurred in Class 16, which had been in residence six weeks. The outbreak continued during the next three months and affected chiefly the older classes Ninety-five cases were diagnosed in the period from November 6, 1944 to January 11, 1945 These were mild and of short duration The disease was characterized by a fleeting, morbilliform eruption, post-cervical adenopathy and a normal or low white blood count with a tendency to lymphocytosis.

3. *Outbreak of Streptococcal Infections* On November 11, 1944, five days after the onset of the German measles outbreak, a new class of 200 men, designated Class 19, arrived at Del Monte from Wright Junior College and Herzl Junior College in Chicago Two men with scarlet fever from this class were admitted directly from the train to the station hospital. Within 24 hours, six more men were admitted and in the week of November 11–18, 14 cases of scarlet fever occurred in this class During the same period, nine other members of this class were admitted for "acute catarrhal fever" and three for German measles

On December 23, 1944, Class 22 arrived from Chicago. Three members of this class had scarlet fever on arrival at Del Monte. These men stated that they had had sore throats on the train. Two other men who had been

in close contact with them developed scarlet fever shortly after arrival. About one week after the arrival of this class, 19 cases of scarlet fever occurred in other classes at Del Monte. The incidence of streptococcal infections increased steadily during the three following months.

4. *Observations on Class 23:* Observations at Del Monte showed that the incidence of streptococcal infections rose sharply after the arrival of classes 19, 22 and 23. The members of these classes came from the Pre-Radio Schools of the Chicago area as is shown in Table 1.

The opportunity to study an entire draft of 196 men, was afforded on January 6, 1945, when Class 23 arrived at Del Monte. About 41 members of this draft had clinical evidence of acute tonsillitis or pharyngitis on arrival. Four were immediately hospitalized for scarlet fever and eight

TABLE 1

Composition of Chicago Drafts—Naval Training School, Del Monte

(Classes 18 through 23)

Class	Date of Arrival	Numbers of Men from Pre-radio Schools			
		Herzl	Wright	Manly	Mich City
18	10-23			155	45
19	11-11	85	115		
20	11-25	20		136	44
21	12-9	79	120		
22	12-23	10		165	25
23	1-6	79	119		

more cases of scarlet fever were diagnosed within 48 hours Moreover, it was learned that two other members of this class became ill with scarlet fever within 18 hours after the train left Chicago on January 2, and were hospitalized at Hastings, Nebraska.

This draft left from two of the Pre-Radio Schools in Chicago, Herzl and Wright, on the night of January 2, 1945 The men were berthed in eight Pullman cars and messed in a diner. The train carried only military personnel and members of the draft waited on tables in the diner A Sick Bay, with a Pharmacist's Mate in charge, was established in one car.

Within 12 hours after departure two men became ill with scarlet fever One man had been complaining of a sore throat at Theodore Herzl Junior College for two days prior to departure During the next three days, six of this man's mates (in Car 3) developed sore throats and scarlatiniform rashes Cases of scarlet fever and acute tonsillitis or pharyngitis also occurred in the other cars

It was possible to locate 156 men according to the cars occupied during

the journey. In every car, at least 10% of the personnel had evidence of acute tonsillitis or pharyngitis. The highest incidence occurred in Cars 3 and 4 in which 35% and 30% of the occupants had acute streptococcal infections.

It was also learned that three porters who attended this draft became ill during the latter part of the journey. They were admitted to the Alameda County Hospital, Oakland, California, on January 6, 1945. Two were treated for acute tonsillitis or pharyngitis and one for acute meningitis due to hemolytic streptococcus. These porters had played cards nightly with the Navy draft during the journey.

In brief, this epidemic of scarlet fever and acute nasopharyngitis in Class 23 began in two men who were recognized to have scarlet fever shortly after departure from Chicago. There was close contact within each car and free movement of personnel and porters from car to car. Comparable conditions existed on the trains which brought Classes 19 and 22 to Del Monte

5 *Bacteriologic Observations*· Throat cultures were made of 389 personnel between January 6 and 11. Hemolytic streptococcus was recovered from 76% of the sick and 26% of the well personnel. The lowest throat carrier rate of 11% was in civilian personnel. The highest rates occurred in Class 23, each member of which was cultured. Hemolytic streptococcus was cultured from 85% of the sick, 42% of the well members and 51% of the entire class. Examination of these cultures showed that the predominant organisms were Re strains of type 19 and that Re strains of type 3 were also present. These strains were indistinguishable from those prevalent at the Pre-Radio Schools of Chicago

In summary, this outbreak of streptococcal diseases at Del Monte followed and appeared to be a direct result of the introduction of acutely ill men and streptococcal carriers from the Pre-Radio Schools of Chicago In spite of the fact that these men were barracked in small groups under satisfactory environmental conditions at Del Monte, their infections spread rapidly. It appeared that these infections were air-borne and coincidentally with the institution of customary measures to minimize the spread of air-borne pathogens there was a rapid fall in the streptococcal morbidity rates. However, while this was occurring, trainees were transferred from Del Monte to the Navy Radio Material School in San Francisco. The arrival of these men was followed by a streptococcal outbreak in the Radio Materiel School. The collected observations indicated that either acutely ill men or carriers spread Re strains of hemolytic streptococcus types 19 and 3 from Farragut, Idaho, to Chicago, Illinois, from Chicago to Del Monte, California, and from Del Monte to San Francisco, California

B OBSERVATIONS AT THE NAVAL TRAINING CENTER, SAN DIEGO, CALIFORNIA

It was possible in most instances to trace the spread of Re strains of types 19, 17 and 3 from points where epidemic conditions prevailed to stations which were free of streptococcal infections caused by Re strains. There was, however, one striking exception. A severe epidemic of scarlet fever occurred at the San Diego Naval Training Center and all attempts to determine its origin failed. Some characteristics of this epidemic were unique in the experiences of the U S Navy during World War II.

1. *Conditions at the U. S Naval Training Center, San Diego* This Training Center, with a complement of over 35,000 men, had three large camp areas, which, though distinct, were continuous All incoming recruits were admitted to Camp Decatur where they were in detention for a period of three to four weeks During this period they received all of their immunizations except the second dose of tetanus toxoid They had no contact with the outside world during these early weeks of training From Camp Decatur they moved a few hundred yards to Camp Farragut[1] where most of the recruit training was done.

There were about 10,000 recruits in training at Camp Farragut (San Diego) in January 1945 None of these men had had liberty since their arrival on the station, their activities had been confined to Camp Decatur and Camp Farragut, where they received a second dose of tetanus toxoid at the Camp Dispensary. Following the completion of four to six weeks' training in Camp Farragut, these men were either transferred to Camp Laurence (the Service Schools) or were detached to duty elsewhere

The living conditions in these training camps at San Diego Naval Training Center were excellent There was no overcrowding Barracks were clean, airy and full of sunlight. December and January were warm and clear months. There was a minimum of dust Most of the classes were held out of doors in the sunlight Morbidity rates for respiratory diseases and streptococcal infections were extremely low at this Center as well as in nearby military and civilian populations.

2 *Description of Streptococcal Respiratory Tract Infections*· Health conditions were excellent at the San Diego Naval Training Center in November, 1944 During the latter part of the month there was an increase in the number of colds and minor respiratory complaints. There was no scarlet fever until a few cases appeared during the second week of December One week later the incidence of streptococcal respiratory

[1] This was a camp at San Diego Naval Training Center and is not to be confused with the Farragut Naval Training Center in Idaho

disease showed a marked increase and the following week scarlet fever reached an epidemic level. The majority of these streptococcal infections were accompanied by a typical scarlatiniform rash. All cases of scarlet fever and nearly all of the throat infections without rash occurred in Camp Farragut among recruits who had been confined to the San Diego Naval Training Center for a period of four to eight weeks.

Over 400 of the 10,000 recruits in Camp Farragut contracted frank streptococcal infections in the first three weeks of the epidemic. The scarlet fever morbidity rate for the entire Center rose by the middle of January to 900. In Camp Farragut, where all of the scarlet fever cases occurred, the morbidity rate exceeded 2,500 during the second week of January. The morbidity rate curves were characteristic of a severe epidemic of air-borne streptococcal infections following an outbreak of colds. These observations are shown in Figure 1. For months these infections remained confined to this camp; there were no cases among the new arrivals in Camp Decatur or in Camp Laurence.

3. *Possible Points of Entry:* Since all men in Camp Farragut had been in training at the Center for at least four weeks they must have been infected in the camp The early infections were not clustered in one barrack but were widely distributed throughout Camp Farragut. These recruits shared only three buildings: (a) they patronized the same Ship's Service (recreational building); however, the Ship's Service building was clean, free of dust, not overcrowded and, so far as could be determined, was not the source of these infections; (b) they ate in the same dining room; however, all of the evidence indicated that this epidemic was not associated with infected milk or other food served in the dining hall or Ship's Service; (c) they attended the same dispensary where it was noted that during November a large number of men with minor respiratory complaints had attended Sick Call. At the Camp Farragut dispensary a large proportion of these men received an ephedrin nose spray and a small number had been placed in bed in the dispensary ward. Several of the corpsmen of the dispensary who cared for these men at Sick Call and in the dispensary ward had come from the Training Center in Farragut, Idaho. The possibility that one of these corpsmen may have been a "dangerous carrier" of hemolytic streptococcus was not considered until after these men had been detached, and for this reason was not excluded.

4. *Four Outbreaks of Surgical Scarlet Fever:* Attention was focused on Camp Farragut dispensary when 85 men developed cellulitis of the arm and surgical scarlet fever. The events in this outbreak were as follows: On January 5, 1945, three recruit companies, about 250 men, were immunized with a preparation of alum precipitated tetanus toxoid. All of these men had received their first immunizing dose about one month prior to

this while in Camp Decatur. The second dose was given in the manner customarily used in Camp Farragut. Tables were placed outside the dispensary in the sunlight and sterile towels were spread on them Six sterile syringes holding 5 cc. each and sterile needles were used. Under

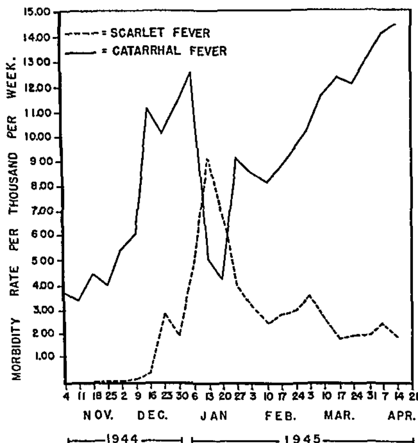


FIG 1 Respiratory Disease Curves during Streptococcal Epidemic at San Diego N T C

the supervision of the dispensary medical officer, who had been in charge of this dispensary for some months, three hospital corpsmen administered the toxoid. This medical officer had had considerable experience with immunization and had taught the three corpsmen the technique of immunizing a large number of men The corpsmen were responsible

for cleansing an area of skin in the deltoid region which was to be injected, the filling of syringes and the administration of 0.5 cc. tetanus toxoid to each man. According to the regulation of the dispensary, only full bottles of toxoid were used. These bottles were kept on the lowest shelf of a small, unlocked icebox in a room of the dispensary where Sick Call was held. The needle was changed after each injection. Six syringes were used throughout the immunization without being resterilized. In the past, this technique for immunization had proved practicable; there had been no infections following immunizations.

On January 6th, severe "reactions" began in two of the three companies immunized. Illness was initiated by symptoms of an acute infection and signs of a severe inflammatory process at the site of injection. It was soon apparent that these reactions were not those commonly associated with immunization and that they had been induced by contamination with a highly pathogenic agent. The appearance of cellulitis at the site of injection and the development of a scarlatiniform rash indicated that the causative agent was hemolytic streptococcus. Within 48 hours of the inoculation two men became critically ill with cellulitis and severe scarlet fever. One of these men died of overwhelming streptococcal toxemia. The gross findings at autopsy were consistent with the clinical diagnosis of fulminating scarlet fever.

Within a period of five days 85 members of Companies 611 and 612 developed signs of cellulitis at the site of inoculation and surgical scarlet fever. Sulfonamide proved ineffective in the treatment of these men but the administration of large doses of penicillin was followed in most instances by a subsidence of the infectious process. However, in some cases abscesses developed and progressed to a point that required surgical intervention. Incision and drainage were followed by the evacuation of pus which on culture yielded in each instance a pure growth of hemolytic streptococcus.

Since all men in one of the three companies immunized escaped infections, it seemed that this outbreak could not be attributed to inoculation of the men during the incubation period of scarlet fever. Cultures of the toxoid bottles were not obtainable because the residual toxoid and the bottles which were used on January 5th had been discarded. However, unopened bottles of toxoid which were to be used for subsequent immunizations were cultured and proved to be sterile. To test the possibility of contamination of toxoid with hemolytic streptococcus, a subculture from an abscess strain was inoculated into one of the 50 cc. bottles of toxoid. At icebox temperature about 90 percent of the organisms died in 18 hours. At room temperature the death rate was greater. Multiplication of this organism in tetanus toxoid did not occur.

Bacteriologic examination of seven cultures of pus obtained on incision of abscesses showed that in each case the microorganism was type 17 and resistant to sulfadiazine 25 mg % The clinical and bacteriologic findings indicated that the microorganisms causing these abscesses were of a single strain and that this strain was identical with the strain which for three weeks had given rise to the epidemic of scarlet fever in Camp Farragut.

One month later a similar outbreak of streptococcal cellulitis and surgical scarlet fever occurred. These infections followed tetanus toxoid injections in the Camp Farragut dispensary. All cultures recovered from these patients were identified as hemolytic streptococcus Group A type 17 Re 25

On March 2, 1945, approximately 900 men of Companies 62, 63, 64, 65, 66 and 67 received yellow fever inoculations and of this group 51 men of Company 63, 26 men of Company 64, four men of Company 66, and one man of Company 67 developed acute infections in the arm at the site of the injection. These injections were all given in Camp Decatur to new recruits in the detention unit where there was no scarlet fever. Thirty of these men developed scarlatinal rashes The organisms recovered from these infections were also type 17 Re 25

On March 6, 1945, approximately 900 men of Companies 68, 69, 70, 71, 72 and 73 received yellow fever inoculations in Camp Decatur and of this group there were approximately 25 acute streptococcal infections at the site of injection These cases occurred mostly in Company 68. The organisms recovered from these infections were also type 17 Re 25

Altogether 21,597 injections of yellow fever vaccine and 43,596 injections of tetanus toxoid were made in the first four months of this epidemic All were given under similar conditions No break in technique was detected The origin of these four outbreaks with more than 200 cases of surgical scarlet fever was not established.

A search was made by the Epidemiology Unit for the empty tetanus toxoid bottles After the first of these outbreaks the three missing bottles were located and identified by their serial numbers These bottles were found charred in an unburned dump of trash Each contained about 1 cc of tetanus toxoid which was heavily contaminated with chains of streptococci The organisms were not viable It appeared that these bottles may have been contaminated purposefully just prior to the administration of tetanus toxoid

5 *Points of Clinical Interest* This Re strain of hemolytic streptococcus maintained its infectivity and pathogenicity for more than one year at San Diego Naval Training Center Four months after onset of the epidemic, high streptococcal morbidity rates persisted Nevertheless, these infections were practically limited to Camp Farragut None occurred in

for cleansing an area of skin in the deltoid region which was to be injected. the filling of syringes and the administration of 0 5 cc. tetanus toxoid to each man. According to the regulation of the dispensary, only full bottles of toxoid were used. These bottles were kept on the lowest shelf of a small, unlocked icebox in a room of the dispensary where Sick Call was held. The needle was changed after each injection. Six syringes were used throughout the immunization without being resterilized. In the past, this technique for immunization had proved practicable; there had been no infections following immunizations.

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In brief, it appeared that a single strain of Group A hemolytic streptococcus type 17 Re 25 caused over 6,000 upper respiratory tract infections, including 1,556 cases of scarlet fever, within four months These streptococcal diseases occurred among recruits who had been restricted to one camp on the station for at least one month. Furthermore, this strain of hemolytic streptococcus caused outbreaks of severe cellulitis and surgical scarlet fever on four occasions following immunizations. The capacity of the strain to induce scarlet fever was great; approximately 20% of men infected by injections developed scarlatiniform rashes In many instances there was marked exfoliation.

SUMMARY

Convincing evidence showed that at Del Monte, Re strains of Group A hemolytic streptococci were introduced into a Naval Activity from the Pre-Radio Schools of Chicago

In contrast, at San Diego all efforts to determine the source of a severe *streptococcal epidemic in the Naval Training Center were unsuccessful* This epidemic had the following distinctive characteristics· (1) It began and persisted under environmental conditions commonly considered unfavorable to the spread of air-borne infections and at a time when streptococcal morbidity rates were minimal at near-by Naval Activities (2) It was caused by what appeared to be a single sulfonamide resistant strain of type 17 hemolytic streptococcus (3) It appeared to originate in men who had attended Sick Call at the camp dispensary with minor respiratory complaints. (4) It originated in and was limited for several months to one camp of men, all of whom had been on the station without outside contact for over three weeks. (5) It was accompanied by four outbreaks of surgical scarlet fever following immunizations. (6) It seemed that these four outbreaks may have occurred as a result of purposeful contamination of biologic materials just prior to immunizations

Camp Decatur and only a few in Camp Laurence (Service Schools) which received men on graduation from recruit training. The sporadic throat infections which occurred among men of the other camps and among station personnel were caused by sulfonamide sensitive strains of serologic types *other than 17.*

There were 1556 frank cases of scarlet fever during the first four months in Camp Farragut. Since only 20% of the men who were infected by immunizations developed a scarlatinal rash, it can be estimated that over 6,000 men contracted streptococcal diseases without a rash This large number of cases of scarlet fever and streptococcal nasopharyngitis without a rash was cared for by 25 medical officers, 18 nurses, 259 medical hospital corpsmen, 165 dental officers, 68 Hospital Corps WAVES and 209 dental hospital corpsmen. Among this professional group of 744 persons having intimate contact with these patients, 1 medical officer, 8 medical corpsmen and 1 dental corpsman developed scarlet fever. The dental officers handled about 950 patients a day and escaped scarlet fever without exception.

TABLE 2

Observations on Types and Sulfonamide Resistance of Cultures of Hemolytic Streptococcus Obtained During the First Months of the Epidemic

No of Cultures	No of Type	% of Type 17	No of Type 17 Tested for Re	No of Cultures Resistant to Sulfadiazine, Mg %				
				0	1	5	25	125
200	186	93	95	0	1	6	85	3

6. *Points of Bacteriologic Interest:* A large number of throat cultures were taken from patients with scarlet fever, tonsillitis and pharyngitis. A small number of cultures were taken from the drainage of patients who developed cellulitis and abscesses following immunization. The pus from these abscesses contained in each instance a pure culture of hemolytic streptococcus type 17 Re 25. The throat cultures from streptococcal patients in Camp Farragut were also identified as type 17 Re 25 except for a small number which were classified as type 17 Re 125 The bacteriologic findings during the first four weeks' period of the epidemic are summarized in Table 2.

About 90% of these were type 17. Only a relatively few of these were tested for resistance. They were classified as either Re 25 or Re 125.

Camp I· Sporadic cases of tonsillitis and pharyngitis occurred during October and reached a high incidence in November. There was only one case of scarlet fever in October. Fifty Group A cultures were identified. Types 19, 6 and 3 were the prevalent types Thirty organisms were tested for sulfonamide resistance, all proved to be sulfonamide sensitive in vitro

Camp II. There was a high incidence of tonsillitis and pharyngitis in this Negro regiment during October and November Scarlet fever was not diagnosed. Of 323 Group A cultures obtained during October and November, 234 were of type 6 Type 19 was also prevalent and other types were found in small numbers Fifty cultures were tested for sulfonamide resistance. All were found to be sulfonamide sensitive except four cultures of type 17 Re 5 in November. The first of these was cultured on November 10, during the last week of November three cultures of type 17 Re 5 were obtained

Camp III There was a high incidence of tonsillitis and pharyngitis and sporadic cases of scarlet fever among these recruits Types 6 and 19 were predominant among the 434 organisms identified serologically. Type 17 was recovered only once in October and six times during the latter part of November. All but two of 63 organisms tested were sulfonamide sensitive strains These two strains were type 17 Re 125. The first of these was obtained on November 17 from a man with nasopharyngitis, who had come from his home in South Carolina eight days prior to this infection. The second culture was obtained on November 30 from a recruit who had been on the station for 19 days.

Camp IV. This regiment had few cases of tonsillitis and pharyngitis, with a single case of scarlet fever Types 19 and 6 were predominant in the 70 Group A organisms examined Type 17 was not recovered All of the nine organisms tested for sulfonamide resistance were sensitive strains.

NAPS Regiment Throat carrier studies were made each month on this group of 690 men The majority of strains of hemolytic streptococcus recovered from the throat flora were not of Group A Among the Group A strains there was no predominant type The types present were 1, 19, 17, 3, 18, 24, 6 and 44 Sulfonamide resistant strains were not recovered in the 17 cultures tested.

B OBSERVATIONS ON THE ACTIVITY OF SULFONAMIDE RESISTANT STRAINS

Streptococcal morbidity rates showed a marked rise at Bainbridge during the winter months In the Service Schools the incidence of scarlet fever rose sharply in November and reached a peak rate of over 400 per 1000 per year during the last week of January In the recruit camps the incidence of scarlet fever rose sharply in January and reached a peak rate of over 300 per 1000 per year during February. (See Chapter VI, Figure 4)

CHAPTER IX

THE SPREAD OF SULFONAMIDE RESISTANT STRAINS OF STREPTOCOCCUS HEMOLYTICUS TO NAVAL ACTIVITIES ON THE ATLANTIC SEABOARD

The largest Training Center for Navy recruits on the Atlantic seaboard was at Bainbridge, Maryland. Adjoining was the Bainbridge Naval Hospital. This Training Center with a population of over 30,000 personnel had a large Service School of about 7,000 men, four recruit camps and a group of about 700 apprentice midshipmen known as "NAPS." The latter trained for nearly one year, the recruits for six weeks and the Service School men for approximately three months.

Streptococcal infections rose to epidemic levels at Bainbridge Naval Training Center during January 1945. The morbidity rate for scarlet fever, which had been low in October and November, reached a peak of over 400 per 1000 per annum in February and then declined sharply. Most of the streptococcal infections of the winter and spring months were caused by Re strains of type 17. These strains were detected at Bainbridge for the first time during November, 1944.

A. INITIAL OBSERVATIONS ON THE APPEARANCE OF SULFONAMIDE RESISTANT ORGANISMS

In October and November streptococcal infections were prevalent at Bainbridge only in the Service Schools Many serologic types of hemolytic streptococcus were present. The clinical and bacteriologic observations made during the fall months were:

Service Schools Tonsillitis and pharyngitis were prevalent during October. In November, the high incidence of these diseases increased and scarlet fever began One hundred and eighty-nine cultures of Group A hemolytic streptococcus from patients with throat infections were examined The predominant types were 19 and 17 Other types were; 6, 3, 30, 12, 29, 18, 44, 1, 5 and uncommon types. Fifty-one cultures were tested for their in vitro resistance to sulfonamide, all were sulfonamide sensitive with the exception of five cultures which were type 17 Re 1. This Re strain was first detected on November 21 In brief, these men with a large number of throat infections had most of the streptococcal types which had been prevalent at Naval Training Centers However, it was not until the last week of November that Re organisms made their appearance.

NAPS Regiment: There were 54 cases of scarlet fever among these 700 men during the winter and spring months. All of these infections were caused by type 17 organisms. The first sulfonamide resistant organisms were obtained during the latter half of December. They were Re 1 and 125. During the winter, 21 cultures were identified as type 17 Re 1, Re 25 and Re 125. All of these organisms came from the throat flora of scarlet fever patients.

Throat cultures were made of each man monthly. The carrier rates for Group A hemolytic streptococcus were: October 6.1, November 10.8, December 11.8, January 8.3, February 19.4, March 31.0, April 30.1. The marked rise in these carrier rates was due to the prevalence of Re strains of type 17 in February, type 3 in March and type 19 in April. The type 17 Re strains were indistinguishable from those which caused scarlet fever among these men. The type 3 was Re 5 and type 19 Re 25. In April there was a new finding: six cultures of type 6 were found to be resistant to 125 mg % of sulfadiazine in vitro. Prior to this type 6 had been recovered only rarely in the cultures from the NAPS and these organisms had been sulfonamide sensitive strains.

C. OBSERVATIONS ON SULFONAMIDE RESISTANT TYPE 6

Sulfonamide sensitive strains of type 6 hemolytic streptococcus had been prevalent at Bainbridge for two years. During the fall months of 1944, type 6 caused most of the streptococcal infections in Camp II. At this time seven cultures showed an in vitro resistance of 1 mg %. Four of these cultures were from the Ship's Company and Service Schools, two from Camp III and one from the NAPS. It appeared that this finding may have been an error in testing because during November, December and January, all type 6 organisms were sulfonamide sensitive. Type 6 Re 125 and Re 25 were first obtained during the third week of February from two acutely ill men who had been in Camps III and IV for several weeks. This organism showed little capacity to spread. It was recovered during March, April and May in thirty one instances. Most of these organisms were classified as Re 125, some Re 25 and a few Re 5. The finding of type 6 Re 125 in the throat flora of healthy NAPS suggested that this strain may have been widely disseminated but of relatively low pathogenicity.

SUMMARY

The 1945 scarlet fever epidemic at Bainbridge NTC began in the Service Schools. About four to six weeks later the incidence of scarlet fever rose rapidly in all recruit camps except the Negro camp. The available information, though not conclusive, suggests that Re strains of type 17 became active first in the Service Schools and later among white men in the recruit

These outbreaks of scarlet fever were accompanied by the appearance of sulfonamide resistant strains of hemolytic streptococci in the throat flora of acutely ill patients and healthy carriers.

Service Schools: These 7,000 men were transfers from several Training Centers. They occupied Camp V and half of Camp I, and attended Sick Call at the dispensaries of these two camps. Types 17 and 19 caused most of the streptococcal infections in these men. Early in December, type 17 Re 1 became prevalent. In January, the common strains were types 17 Re 1, Re 5, Re 25 and Re 125. In February, these strains persisted and type 19 Re 25 appeared. Re strains of type 3 were rare in over 200 cultures examined.

Camp I: Tonsillitis and pharyngitis were prevalent in this camp during November. The morbidity rates for scarlet fever rose sharply during the first half of December among these 1600 men. Sulfonamide resistant organisms appeared also during the last half of December. These resistant strains were all of type 17, Re 25 and Re 125. They appeared at the same time and remained predominant throughout the spring months. Resistant strains of types 19 and 3 were conspicuously absent.

Camp II: This camp with about 4500 Negro recruits had a high incidence of tonsillitis and pharyngitis in November and December but escaped the epidemic of scarlet fever which spread throughout all other camps on the station. Only three cases of scarlet fever were recognized. Types 6, 19, and 17 were prevalent in the throat flora of men with tonsillitis and pharyngitis Resistance tests were made between December and April of only 18 cultures Type 17 Re 25 was recovered on December 30 and two cultures of type 17 Re 5 during January. In April most of 17 cultures examined were sulfonamide resistant organisms of type 17 Re 125 and Re 5, type 3 Re 25 and type 6 Re 125

Camp III. The incidence of tonsillitis and pharyngitis was high among these 5,000 recruits in December Morbidity rates for scarlet fever began to rise early in January. During December only a few cultures were typed and tested for sulfonamide resistance. Strains of type 17 with a resistance of 5 mg. % were present in early December. Between January and April, the predominant organism was type 17 Re 5. In April, nearly all of the organisms tested were sulfonamide resistant strains of type 17 Re 25, type 19 Re 25 and type 6 Re 25.

Camp IV The morbidity rates for streptococcal infections among these 4,000 recruits ran a parallel course to those of Camp III. Only a few cultures were tested for sulfonamide resistance The first resistant strain was obtained during the last week of December from a patient with scarlet fever It was type 17 Re 5. This organism was predominant in January and February. Type 17 Re 25 and Re 125 were also prevalent and in April two cultures were identified as type 6 Re 25.

CHAPTER X

THE SPREAD OF SULFONAMIDE RESISTANT STRAINS OF STREPTOCOCCUS HEMOLYTICUS TO NAVAL ACTIVITIES IN THE NORTHEAST

Streptococcal infections were prevalent at Naval Activities in the Northeastern states during the spring months of 1943 and 1944. High morbidity rates occurred at Sampson Naval Training Center situated in the Finger Lake region of Northern New York State This Center, with a population of over 30,000 men, contained five recruit camps, a Service School camp and was contiguous to a large Naval Hospital Studies were initiated at this Center in October, 1944 to determine whether Re strains of hemolytic streptococcus were present or whether they would appear in the throat flora of the personnel at Sampson

A PRELIMINARY OBSERVATIONS

The clinical and bacteriologic observations made in October and November, 1944 were briefly as follows:

1. *Camp Scott* (Service Schools). Sporadic cases of tonsillitis and pharyngitis occurred among these men who came to Sampson from several training stations However, there were no cases of scarlet fever. The types of hemolytic streptococcus cultured from fifteen patients with acute throat infections were 3, 30, 17, 24, and 44 Nine cultures were tested for sulfonamide resistance. No strains were resistant in vitro Type 19 was not recovered

2 *Camp Callahan* Streptococcal throat infections including scarlet fever appeared and increased rapidly during October The morbidity rates for streptococcal diseases reached an epidemic level during the early part of November. Type 30 was predominant, other prevalent types were 44 and 3 Type 19 was present in three cultures, type 17 was not recovered Ninty-three cultures were tested for sulfonamide resistance All were sulfonamide susceptible in vitro with the possible exception of one culture of type 36

3 *Camp Dewey* There was a moderate incidence of streptococcal throat infections but no scarlet fever until the last week of November. One hundred and fifty-five cultures were examined. The predominant organism was type 3 Other prevalent types were 6, 5, 12 and 1 Type 19 was recovered only twice; no cultures were identified as type 17. No sulfonamide resistance tests were made

camps The Service Schools were composed of men who had completed recruit training at several Training Centers. Throat culture studies made in November and December, 1944, of healthy men arriving in the Service Schools from Farragut, Idaho showed that a high percentage of each draft carried Group A hemolytic streptococcus. At that time most of the Farragut streptococcal carriers had sulfonamide resistant organisms.

Most scarlet fever at Bainbridge in the winter months of 1944–45 was caused by sulfonamide resistant strains of type 17. However, during the spring months type 19 Re 25 and type 3 Re 5 also became prevalent in some of the recruit camps and among the NAPS. The early Re strains appeared not only in the Service Schools but also among a few men who had arrived recently from civilian life and were assigned to Recruit Camps II and III. The organisms appeared to spread rapidly in the Service School.

A new finding was made during the winter and spring months of 1945. Type 6 Re 125 was cultured from recruits with acute throat infections and healthy carriers among the NAPS. It appeared that this Re organism may have had its origin at Bainbridge during the winter months of 1945. Whether it was introduced by a healthy carrier entering recruit training or represented a change in type 6 which had long been sulfonamide sensitive at Bainbridge could not be determined.

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A. PRELIMINARY OBSERVATIONS

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4. *Camp Gilmore:* Streptococcal throat infections occurred sporadically. There were no cases of scarlet fever. Type 3 was the predominant organism among 23 cultures examined. A number of other types were recovered; however, types 19 and 17 were not identified. All of the 11 organisms tested were sulfonamide sensitive in vitro.

5. *Camp Farragut:*[1] Streptococcal throat infections occurred sporadically. There were no cases of scarlet fever. There was no predominant type in 30 cultures examined. All of the 18 organisms tested were sulfonamide sensitive.

6. *Camp Edwards:* Streptococcal throat infections occurred sporadically and during the latter part of November there were three cases of scarlet fever. Type 44 was predominant. Types 19 and 17 were not recovered. Fourteen organisms were tested for sulfonamide resistance. All were sulfonamide sensitive in vitro.

B OBSERVATIONS ON THE APPEARANCE OF SULFONAMIDE RESISTANT ORGANISMS

Activity of hemolytic streptococcus had become apparent early in the fall months of 1944 at Sampson Naval Training Center. Several serologic types were identified as the causative agents. Types 19 and 17 were, however, either rare or absent. Among 141 organisms tested for sulfonamide resistance, none (with the possible exception of one type 36 organism noted) was resistant to sulfonamide in vitro

The bacteriologic findings began to change at Sampson during December, 1944. (See Chapter VI, Figure 3.) The first change was noted in the Service Schools where recruits from other Training Centers were given special instruction Scarlet fever and type 19 organisms had not been observed in this camp until December 10. On December 10 the first case of scarlet fever occurred. The causative agent was type 19. During the remainder of December type 19 was identified in seven cultures. Five of these patients had scarlet fever No sulfonamide resistance tests were made of these seven cultures. Type 19 became the predominant organism in the Service Schools during January This type was identified in 25 cultures and 24 of these were tested for sulfonamide resistance. Sixteen were resistant in vitro to 5 mg %; six to 1 mg %; two appeared sulfonamide sensitive. Twenty of these 25 cultures were from patients with scarlet fever. In summary, scarlet fever made its appearance in the Service Schools (Camp Scott) on December 10 and spread progressively. The causative agent was type 19, either Re 5 or Re 1 in the majority of cases

[1] This was one of the recruit camps at Sampson and is not to be confused with the Naval Training Center at Farragut, Idaho.

Type 17 made its appearance in the Service Schools on or about February 12 This organism was recovered first from a patient with a mild upper respiratory tract infection diagnosed as "catarrhal fever" This type 17 organism was Re 125 Five other cultures of type 17 were recovered in February All of these patients had scarlet fever and all of these type 17 organisms were either Re 125 or Re 25.

Streptococcal infections characterized by a high incidence of scarlet fever spread through the recruit camps during the last week of January. Morbidity rates reached a peak in March and continued elevated throughout the spring months Observations made in the recruit camps were briefly as follows.

Camp Callahan· Type 19 Re 5 appeared during the second week of February and type 17 Re 125 on March 13

Camp Dewey: Type 19 Re 1 and Re 5 appeared during the second and third weeks of January and became the predominant organisms Re strains of type 17 were recovered during the winter months

Camp Gilmore: Type 19 Re 1 and Re 5 appeared during the third week of January and became the predominant organisms Type 17 Re 125 was recovered on March 16

Camp Farragut Type 19 Re 5 and Re 1 appeared during the last week of January and second week of February. These organisms became predominant Type 17 Re 125 was recovered on March 23

Camp Edwards: Type 19 Re 1 appeared during the third week of January No type 17 streptococci were recovered The predominant strains were type 19 Re 1 and Re 5 There were relatively few streptococcal infections in this camp during the winter and spring months

The first Re strains at Sampson were detected in the Service Schools composed of men transferred from several training stations Almost no bacteriologic information was available on the throat flora of these transfers into the Service Schools. Attention was called, however, by the Epidemiology Unit stationed at Farragut, Idaho to the fact that a carrier of type 19 Re 5 (an organism which was prevalent at Farragut) was being transferred to Sampson This man (J M L) went on duty in the Service Schools at Sampson, December 5, 1944 Attention was also called by the Epidemiology Unit at Sampson to the fact that on February 1, 1945, a new arrival in the Service Schools carried in his throat flora hemolytic streptococcus type 17 Re 125 This man came from the Great Lakes Naval Training Center, where this organism was prevalent. Type 19 Re strains became *predominant, type 17 did not spread at Sampson*

SUMMARY

Hemolytic streptococcus type 19 Re 1 and Re 5 caused an epidemic at Sampson NTC in 1945

The initial infections occurred in the Service Schools, and began with the appearance of scarlet fever five days after the arrival of a known carrier of type 19 Re 5 from Farragut, Idaho, which at that time was the only Training Center where Re strains of type 19 were prevalent.

The arrival later of a man from the Great Lakes Naval Training Center with type 17 Re 125 was followed by several cases of type 17 Re 125 infections in the Service Schools during February. Sporadic infections caused by type 17 Re 125 were observed in several recruit camps during March, however, this organism did not become widely disseminated.

Type 19 Re 1 and Re 5 strains appeared in recruit camps between the middle of January and the middle of February.

These observations indicated that at least one Re strain of type 19 was introduced into the Service School camp of Sampson and spread throughout recruit camps, and that later one Re strain of type 17 was introduced into the Service School camp but failed to spread. It appeared that type 19 Re 5 was introduced by a Farragut transfer and type 17 Re 125 by a Great Lakes transfer.

CHAPTER XI

THE SPREAD OF SULFONAMIDE RESISTANT STRAINS OF STREPTOCOCCUS HEMOLYTICUS TO NAVAL ACTIVITIES IN THE SOUTH

Early in 1944 there were severe outbreaks of streptococcal infections at the Naval Air Technical Training Centers (NATTC) in Norman, Oklahoma and Memphis, Tennessee. Each was accompanied by an increase in the incidence of scarlet fever to epidemic proportions These outbreaks occurred when scarlet fever was either absent or minimal in the near-by Naval installations and in the civilian population Clinical and bacteriologic observations indicated that they were caused by the introduction of highly infectious bacterial agents prevalent among drafts of men arriving from Recruit Training Centers Studies were initiated at both of these Air Centers during the fall months of 1944 to determine whether the events of the previous winter would recur in 1945 and whether Re strains of hemolytic streptococcus would appear.

A OBSERVATIONS ON THE APPEARANCE OF SULFONAMIDE RESISTANT STRAINS OF HEMOLYTIC STREPTOCOCCUS AT NORMAN NATTC

Norman had a strength of about 15,000 men. At the time of this study, recruit training had been discontinued on this station Incoming drafts were either from Recruit Training Centers or from overseas In addition to the Ship's Company there were three camps of enlisted men receiving training comparable to that given at the Service Schools of Training Centers

The incidence of streptococcal infections was low at Norman during the summer and fall months of 1944 Sporadic nasopharyngeal infections were caused chiefly by hemolytic streptococcus types 19 and 17 and to a lesser degree by types 5, 6 and 24 Nine surveys of the throat flora of incoming drafts were made during these months The carrier rate for hemolytic streptococcus Group A fluctuated little from a median of 5% All strains of hemolytic streptococcus from patients and carriers were sulfonamide sensitive in vitro. The earliest cases of scarlet fever occurred in each of the three training camps during the last week of November Morbidity rates for all streptococcal infections remained low until the last week of December, 1944

A sudden clinical change began at Norman during the third week of December, 1944.

(1) In Camp III the morbidity rates for streptococcal infections rose rapidly, reaching a peak rate of 1,500 per 1000 per annum on February 2. Scarlet fever, which had been absent during the middle of December, rose to a peak rate of 494 in the middle of February.

(2) In Camp II the morbidity rates for streptococcal infections rose to a comparable degree one week later than in Camp III. Scarlet fever, which had been absent during the middle of December, rose abruptly two weeks later and reached a peak of 272 during the middle of March.

(3) In Camp I the morbidity rates for streptococcal infections also rose abruptly during the last week of December and reached a peak rate of over 1,100 on February 2. Scarlet fever which had been absent during the middle of December appeared two weeks later and reached a peak of 346 during the middle of March.

These three parallel outbreaks of streptococcal infections in the training camps at Norman accompanied striking changes in the character of the throat flora of incoming drafts, patients and healthy personnel. The Group A streptococcal carrier rates among men on the station increased progressively from 5% during the last week of December to 27.5% late in March The highest carrier rate recorded was 34.3% in a Farragut draft of 35 men. Whereas all strains of Group A hemolytic streptococcus tested prior to December 15, 1944 had been sulfonamide sensitive, the epidemic rise was associated with hemolytic streptococci of type 17 Re 125 and type 3 Re 5 and was followed by the appearance of type 19 Re 1 and Re 25. Prior to the epidemic outbreak, no Re strains of type 17 had been recovered on this Center, following the onset of the epidemic, type 17 became predominant with all organisms resistant in vitro to 125 mg % except one culture which had a resistance of 25 mg. %.

It appeared that this epidemic outbreak was initiated by type 17 Re 125 and type 3 Re 5 and maintained by these organisms and type 19 Re 1. It seemed that these organisms had become widely spread over the station Throat cultures were taken at random from men occupying 18 barracks in Camps II and III Fifty of 204 men had Group A hemolytic streptococcus in their throat flora. Sulfonamide resistant organisms were recovered from men in all barracks but four from which only one culture each was available for testing Sixty percent of 48 cultures tested were sulfonamide resistant. These organisms were of type 17 (11 cultures, 100% resistant), type 3 (15 cultures, 80% resistant), type 19 (18 cultures, 33% resistant).

This epidemic outbreak occurred at a time when the carrier rate for hemolytic streptococcus was being maintained at a constantly low level of 5%. It accompanied the appearance of strains of streptococci which had not been detected on the station prior to the outbreak. It appeared

that Re strains may have been introduced by incoming drafts. The complement and point of origin of drafts which reached Norman in December and January are shown in Table 1 In December, 1944, the only Recruit Training Center Outgoing Unit which was known to carry sulfonamide resistant strains of hemolytic streptococcus was Farragut, Idaho In January, Re strains of types 3, 17 and 19 were also prevalent at Great Lakes, Illinois

In summary, streptococcal outbreaks occurred almost simultaneously during the last half of December, 1944, in the three camps of Norman NATTC. These outbreaks accompanied the appearance of sulfonamide resistant strains of hemolytic streptococcus which had not been detected previously on this station. It appeared that they might have been introduced by incoming drafts The only drafts of men known to carry these

TABLE 1

The Point of Origin and Strength of Drafts Received at Norman Before and During the Streptococcal Outbreak

	Sampson	Great Lakes	Farr	San Diego	Bainbridge	Memphis	Others	Total
December 1944	179	381	89	100	58	579	17	1404
January 1945	376	678	158	203	122	775	51	2363

strains prior to the onset of this epidemic were those from Farragut, Idaho

B OBSERVATIONS AT MEMPHIS NATTC ON THE APPEARANCE OF HEMOLYTIC STREPTOCOCCUS TYPE 17 RE 125

This station was a Naval Air Technical Training Center similar to the Activity at Norman The average strength in the fall of 1944 was about 12,000 In addition to Ship's Company there were four camps One was used for recruit training. The others were used for training machinist mates, radio men, radar men, ordnance men and mess cooks In one camp Marines were barracked together in one section and Negro personnel were in another part Except for the recruits, the training was similar to that at Norman and comparable to that at Service Schools of Training Centers

The incidence of streptococcal infections was low during the fall months of 1944 Two men (*L A N and W. B V*) *on arrival in October from* Farragut, Idaho, were shown to be carriers of hemolytic streptococcus, type 19 Re 5 These organisms did not spread and there were no more

arrivals from Farragut after November. The sporadic streptococcal infections of the fall months at Memphis were caused by a number of serologic types, principally, types 19 and 6 All of the organisms tested were sulfonamide sensitive in vitro

A sharp rise in the streptococcal morbidity rates occurred throughout the station during the last half of December. These infections were due chiefly to types 19 and 6 Two type 17 cultures were obtained at this time in a group of men who had arrived from Great Lakes. All organisms tested in December were sulfonamide sensitive in vitro.

On January 9, 1945, a draft of 254 men arrived from the Outgoing Unit of Great Lakes. Fourteen radio men from this draft were placed in barracks #54 and 240 Ship's Cooks in barracks #15. The first sulfonamide resistant strains cultured were from two radio men with acute tonsillitis The organism was type 17 Re 125. The date was January 31. Both of these cultures were from new arrivals in the Great Lakes draft on January 9, living with other Great Lakes men in barracks #54. Another type 17 Re 125 infection occurred a few days later. This was in a Mess Cook who had come from Great Lakes and lived with Great Lakes men in barracks #15

Memphis had been almost free of scarlet fever prior to January. Those cases which occurred prior to January 31 were caused by sulfonamide sensitive type 19. In February and March there was a striking change in the throat flora. This was accompanied by an increase in scarlet fever due to type 17 Re 125 among radio men and in the barracks where radio men were placed

The Ship's Cooks remained in barracks #15. Only two more type 17 Re 125 infections occurred in this barrack. These were in men who had been recently transferred from barracks occupied by radio men. One type 17 Re 125 infection occurred among the WAVES, a WAVE hospital corpsman who worked in dispensary B, used exclusively by sick radio men. No type 17 infections occurred during the next twelve weeks in the recruits, Marines, Negro battalion, Ship's Company, machinist mates or radar students. The type 17 Re 125 infections were limited, with the exceptions noted, to radio men and spread as the radio men were moved from barrack #54 to other barracks These observations are illustrated in Figure 1.

In summary, a severe outbreak of streptococcal infections with a high incidence of scarlet fever occurred at Memphis during the winter of 1945. The predominant organism was type 17 Re 125 The outbreak was limited to radio men and their contacts It did not spread to the Recruit Camp. The findings indicated that this bacterium was introduced from Great Lakes Naval Training Center by carriers or their contaminated gear

Fig 1 Passage of an Epidemic Strain from Great Lakes N T C to Areas of Memphis N A T T C

SUMMARY

Streptococcal outbreaks occurred during the winter months of 1945 at Norman NATTC and Memphis NATTC. These two Centers were similar in plan, in personnel, in training and in the latitude of their location

At Norman, the streptococcal outbreak was caused by a number of Re strains apparently introduced by drafts of men from Farragut and Great Lakes These strains spread throughout the Center.

At Memphis, the streptococcal outbreak was caused by type 17 Re 125 introduced from Great Lakes. This strain was passed from barrack to barrack by radio men but did not spread to other camps on the Center. Possible reasons for this difference in spread at these two Centers are dealt with in Chapter XII.

Attention is drawn to the fact that in October, 1944 type 19 Re organisms were introduced into Memphis NATTC from Farragut, Idaho, that they had appeared highly communicable at Farragut, and that they failed to cause a single infection at Memphis

CHAPTER XII

A COMPARISON OF CONDITIONS AND OCCURRENCES AT SIX NAVAL ACTIVITIES WHERE SULFONAMIDE RESISTANT STRAINS OF STREPTOCOCCUS HEMOLYTICUS SPREAD RAPIDLY IN THE WINTER MONTHS OF 1945

There was a sharp rise in the streptococcal morbidity rates during the last week of 1944 at each of the Navy's large training stations, except Farragut where recruit training had been discontinued Each outbreak of streptococcal disease resulted from the spread of sulfonamide resistant organisms to stations located in Illinois, California, New York, Maryland, Oklahoma and Tennessee Chemoprophylaxis was being administered at some of these Activities and not at others This variable was discussed in Chapter VI In most instances, Re strains of hemolytic streptococcus were disseminated rapidly through an entire station There were exceptions, however, and it is of particular interest to determine why these exceptions occurred.

A. THE EPIDEMIC SPREAD OF RE STRAINS OF HEMOLYTIC STREPTOCOCCUS AT THE GREAT LAKES NAVAL TRAINING CENTER

1 *Sequence of Spread*

Weekly morbidity rates for scarlet fever rose precipitously during the last week of December, 1944 in Camps Dahlgren and Hull. One week later there was a similar precipitous rise in Camp McDonough and less intense rises in Camps Porter and Decatur. The following week precipitous rises occurred in Camps Moffett, Mahan, and Maury Rises in the scarlet fever morbidity rates in Camps Downes and Dewey occurred during the last week of January Camp Robert Smalls, the Negro recruit regiment, escaped an outbreak of streptococcal infections The curve of scarlet fever morbidity rates for the individual recruit camps is shown in Chapter VI, Figure 2.

These figures illustrate the rapidity with which strains of hemolytic streptococcus spread over widely separated areas of the Great Lakes Naval Training Center Within six weeks all but Camp Smalls had high scarlet fever morbidity rates

2 *Predisposing Conditions*·

(a) Technique for cleaning floors: A great effort was made at Great Lakes to have a high polish on floors in the barracks and in the wards. The floors were scraped with steel wool and dry swept before bed time

when the barracks were filled with men. In the wards of the McIntyre Dispensary, the floors were dry-swept and once a week on "Field Day" beds were moved about so that the floors might be polished for Captain's Inspection.

(b) Training Program: The training schedules were so arranged that new companies, composed mostly of personnel under 19 years, were seeded each week in the various camps. These new arrivals were placed in contaminated barracks and brought into close contact with men in the incubation and recovery stages of streptococcal infections. *In this way each camp was an open colony replenished weekly with fresh susceptibles*

(c) Sick Call: Large groups of men were brought into close contact in the corridors of a camp dispensary several times each day during the cold months. There they not only were exposed to cases of acute upper respiratory tract infections but also received thermometers and nasal sprays which, in some instances, were contaminated with hemolytic streptococcus

(d) Hospital Care: Facilities for aseptic precautions were not available. Men from all camps were crowded together in open wards filled to more than twice their planned capacity.

There was only one exception in the rapid spread of hemolytic streptococcus at Great Lakes Camp Smalls escaped the epidemic outbreak. Scarlet fever was difficult to diagnose in the Negro Undoubtedly, Negro recruits with this disease were treated for acute pharyngitis in the camp dispensary Because of this they did not come into contact with other scarlet fever patients in the wards of the McIntyre Dispensary.

B THE EPIDEMIC SPREAD OF TYPE 17 RE 25 AT THE SAN DIEGO NAVAL TRAINING CENTER

A streptococcal epidemic began in Camp Farragut of this station during the third week of December, 1944 All barracks were involved. So far as could be determined, this epidemic was due to a *single type 17 Re 25* strain. Scarlet fever was absent in neighboring Naval Activities and for several months this disease was limited to Camp Farragut.

The personnel of the San Diego Naval Training Center lived under excellent environmental conditions Most classes were held outdoors and blankets were aired in the warm sunshine. These recruits had the usual meeting points of Ship's Service, class rooms, dining hall and dispensary. Just prior to this outbreak there had been a high incidence of "colds." The Sick Call had been heavy and a large proportion of the men received nasal sprays The camp dispensary ward had been filled with patients who had minor upper respiratory tract infections.

No Naval training group was so carefully segregated as these men in Camp Farragut. All new personnel were admitted to the adjoining Camp

Decatur and "quarantined" there for four weeks prior to entering Camp Farragut. The only recognized potential hazard was the dry sweeping of barracks which became dusty in this warm, sunny climate. Nevertheless, this strain of type 17 Re 25 hemolytic streptococcus became widely disseminated. Sick men in this camp did not come in contact with men of the other camps at San Diego and for a period of several months scarlet fever was limited to Camp Farragut

C. THE EPIDEMIC SPREAD OF RE STRAINS OF HEMOLYTIC STREPTOCOCCUS AT THE SAMPSON NAVAL TRAINING CENTER

Epidemic conditions at Sampson in the fall months of 1944 differed from those of other Naval Training Centers in that there was a high incidence of scarlet fever in one camp (Callahan). By December the annual morbidity rate per 1000 in this camp exceeded 400. These infections were caused by sulfonamide sensitive strains, chiefly of type 30 There seemed to be little tendency to spread from this camp at this season

A slow progressive rise in the scarlet fever morbidity rates began during the last week of December in the Service Schools (Camp Scott). A peak of about 350 was reached during the middle of February It was in these Service School men that sulfonamide resistant strains, first type 19 and later type 17, made their appearance. Service School men with streptococcal throat infections were treated in a group of "Bethesda type" wards in the H and S areas at Sampson

Three recruit camps at Sampson were handled along similar lines They were Camps Gilmore, Farragut and Edwards In each of these camps one of the two dispensaries had been closed in the fall months of 1944 because of shortage of medical personnel During January and early February 1945, recruits were confined to an indoor life, outside activities were prevented by heavy snowfalls Environmental conditions were comparable to those at Great Lakes

At the beginning of the year 1945, Camps Gilmore and Farragut experienced outbreaks of severe "colds" and German measles Men with these infections were treated in the Bethesda type wards shared by sick personnel from the Service Schools Camp Edwards escaped German measles and the personnel were treated mainly in their camp dispensaries

Explosive outbreaks of scarlet fever began during the middle of January in both Camps Gilmore and Farragut In each camp the morbidity rate rose to a peak of over 700 during the second week of March The causative agent for each of these outbreaks was type 19 Re 1 This organism spread early in February to Camp Edwards. During the latter half of February the scarlet fever morbidity rate for Camp Edwards rose slowly to a peak of

250 in the middle of March. The morbidity rate curves for scarlet fever in these three camps are shown in Chapter VI, Figure 3.

So far as could be determined, there were only two differences between the conditions existing in these three recruit camps. Gilmore and Farragut had had outbreaks of German measles and upper respiratory tract infections. While ward patients, these recruits had close contact with patients from the Service Schools where infections caused by type 19 Re 1 first appeared, the epidemic rise of streptococcal infections in Camps Gilmore and Farragut were caused by type 19 Re 1.

D. THE EPIDEMIC SPREAD OF RE STRAINS OF HEMOLYTIC STREPTOCOCCUS AT THE BAINBRIDGE NAVAL TRAINING CENTER

The spread of streptococcal infections in the recruit camps at this station was comparable to the spread at Great Lakes High scarlet fever morbidity rates in the Service Schools preceded by one month similar rises *in recruit camps During January 1945, each recruit camp had an epidemic* outbreak of scarlet fever which was caused first by Re strains of type 17 and later by Re strains of types 19 and 3 The peak rate for scarlet fever in the recruit camps occurred in February, following the peak rate for measles and coincident with that for mumps and all respiratory tract infections

The Negro camp of recruits escaped the winter epidemic rise of streptococcal infections and it was not until the spring months that Re strains became prevalent in this camp. That these men were susceptible to streptococcal infections was evidenced by the fact that during the fall months of 1944 the highest incidence of tonsillitis and pharyngitis occurred in this camp The causative agents were sulfonamide sensitive strains of type 6 hemolytic streptococcus Streptococcal infections were treated in the camp dispensary ward and there was little contact between the Negro patients and scarlet fever patients from other camps of the station

The only occurrence at Bainbridge which was different from that observed at other stations was the appearance of type 6 hemolytic streptococcus resistant to 125 mg % sulfadiazine when the incidence of streptococcal infections was subsiding on the Center Although type 6 Re 125 appeared sporadically in several camps there was little tendency to spread even though conditions had favored the rapid passage of hemolytic streptococcus

E. THE SPREAD OF RE STRAINS OF HEMOLYTIC STREPTOCOCCUS AT NORMAN AND MEMPHIS NAVAL AIR TECHNICAL TRAINING CENTERS

These two training centers were similar. The points in common were size of drafts received, latitude, climate, size, type of training, and procedures for cleaning of barracks

The obvious differences were: Memphis had a regiment of recruits from civilian life, Norman had none. The trainees at Memphis came from within the continental limits; about half of the trainees at Norman were seasoned men who had served overseas At Memphis there was a large group of radio men, at Norman there were no radio men. At Memphis there was segregation of groups, such as recruits, Marines, Negro personnel, radio men and WAVES. Each group was treated at Sick Call in its own camp dispensary. Radio men used only dispensary B. Marines used dispensary C. WAVES used dispensary A Negroes used restricted portions of dispensaries D and C. At Norman, the enlisted personnel were barracked in three camps; there was no segregation; the men shared common class rooms. Furthermore, all men with complaints of respiratory tract diseases were treated at one dispensary. The other two dispensaries were used for special examinations, surgical and venereal diseases.

At Memphis the dissemination of contaminated dust particles was reduced to a minimum Barrack floors were treated with steel wool only on Tuesday at a time that they were vacant and the windows were open. The floors were then given a heavy coat of wax. The dispensary floors, including wards, were all covered with green battleship linoleum (Navy Supply number 27-L-514) and not with asphalt squares containing dust in the cracks between squares. Furthermore, the linoleum covered floors were cleaned frequently with a green sweeping compound (Navy Supply number L51-C-1621) and there was little dust in the air of dispensaries At the Norman dispensary, floors were covered with asphalt tile squares which permitted the infiltration of dust into the cracks.

There was a striking difference in the spread of hemolytic streptococcus at these two Centers. Re strains became widely distributed throughout all personnel at Norman and remained prevalent at least until June. Infections with type 17 Re 125 at Memphis were limited, with two exceptions, to the radio men They did not penetrate the recruits' regiment and disappeared during the spring months

A comparative study of streptococcal outbreaks at these two stations led to the following conclusions:

1 The onset of cold weather was accompanied by outbreaks of mild upper respiratory tract infections at both stations

2 This was followed by the appearance of sulfonamide resistant strains; at Memphis, type 17, and at Norman, types 17, 3 and 19

3 These strains appeared after the [illegible]

when the hemolytic streptococcal carrier rate was 20% and at Norman when the carrier rate on the station was over 5% in most groups.

5. The spread of Re strains at Memphis was limited, with two exceptions, to the barracks of radio men. At Norman, the spread was stationwide.

6. Recruits at Memphis escaped infections with Re strains Seasoned personnel at Norman contracted infections with these strains

7. At Memphis each group attended its own dispensary; other personnel had little contact with sick radio men. At Norman, all groups of personnel were exposed to Re infections; all patients with respiratory tract diseases were treated together in one dispensary.

SUMMARY

Basic conditions at Naval Training Centers during the winter months of 1944–45 permitted the rapid dissemination of Re strains of hemolytic streptococcus.

Barrack-to-barrack spread occurred within a fortnight in most camps, and camp-to-camp spread occurred within six weeks at most stations. There were, however, four exceptions:

1. Negro regiments at three stations either escaped infections with Re strains or had sporadic infections after the epidemic had subsided.

2 A recruit camp at Sampson Naval Training Center experienced only a mild outbreak of streptococcal diseases late in the epidemic wave

3 Two of the three camps at San Diego Naval Training Center escaped Re infections during the epidemic.

4 The spread of a Re strain at Memphis was limited to barracks in which radio men were quartered.

Freedom from exposure to acutely ill or convalescent patients in the dispensary or in the scarlet fever wards of the Naval Hospital appeared to be a significant differential point

The findings indicated that the camp dispensary may have facilitated the barrack-to-barrack spread and the scarlet fever wards of the Naval Hospital may have facilitated the camp-to-camp spread throughout Naval Training Centers.

CHAPTER XIII

OBSERVATIONS ON THE INFECTING AGENTS IN RELATION TO THE INITIATION OF STREPTOCOCCAL OUTBREAKS DURING THE LAST YEAR OF WORLD WAR II

Observations on epidemics of scarlet fever are made in most instances after the seriousness of an outbreak is recognized On these occasions, infections are widely disseminated and the streptococcal carrier rate is frequently high It is then difficult to trace the spread of contagion and usually impossible to get conclusive information on the origin of the epidemic To the student of streptococcal diseases, no task seems more challenging than defining the significant factors in the genesis of streptococcal epidemics

It is well recognized that factors associated with the genesis of streptococcal outbreaks vary from one epidemic to another. In 1918 hemolytic streptococcal outbreaks were associated with the pandemic of influenza. Less severe outbreaks have occurred in the wake of measles, the common cold and other viral infections of the respiratory tract. Clinical observations indicate that respiratory tract viruses may be a factor in the genesis of streptococcal outbreaks and experimental evidence has shown that influenza virus infections in the ferret may permit secondary infections with hemolytic streptococcus and the spread of this bacterium (20). In the United States streptococcal epidemics usually occur during the winter or early spring months when climatic conditions seem to favor the genesis of outbreaks of respiratory tract infections However, streptococcal outbreaks do occur when carrier and morbidity rates are minimal, when virus diseases of the upper respiratory tract are not evident and when Group A hemolytic streptococcus is introduced by a single "dangerous carrier" (21) Under these conditions, the communicability of the epidemic strain of hemolytic streptococcus appears to be the critical factor initiating the epidemic

During World War II, the Navy Epidemiology Units made observations prior to, at the onset of and during streptococcal outbreaks at stations situated in every Naval District of the United States. The fact that certain types of hemolytic streptococcus were causing the majority of infections at Naval Training Stations was soon recognized At Newport, type 6 predominated and in the Chicago area, types 17 and 3 were most prevalent The first single type epidemic (15) recorded in the Navy began in

September, 1942, on Receiving Ship, New York (Pier 92). The earliest cases of scarlet fever in this outbreak occurred sporadically and it was not until the onset of cold weather in November that scarlet fever morbidity rates increased so rapidly that epidemic conditions were recognized. One of the earliest as well as the majority of cases occurred in the radio school. The causative agent was Group A hemolytic streptococcus type 19. Throughout the epidemic this organism showed a capacity to induce a scarlatiniform rash and produced in vitro a high concentration of erythrogenic toxin (40,000 S.T.D. per 1 cc. of filtrate). This epidemic was considered to be air-borne; its origin was not determined.

Comparable single type epidemics of air-borne infections occurred in the various camps at Naval stations throughout the United States in 1943 and in 1944. The serologic typing of throat strains of hemolytic streptococcus cultured before, at the onset of and during an epidemic clearly showed that in many instances an outbreak was caused by a single type. However, it was not until the fall months of 1944 that it became possible to determine whether an epidemic was caused by multiple or perhaps a single strain of one serologic type of hemolytic streptococcus. For this reason, deductions will be limited chiefly to observations made during the last year of World War II.

A. CONTRIBUTING FACTORS IN STREPTOCOCCAL OUTBREAKS

Dudley (22) has called attention to a number of conditions which predispose to outbreaks of respiratory tract infections Findings in the U. S. Navy during World War II are in accord with his opinion. The contributing factors appeared to be:

1. *Climate, Season and Location:* The epidemics in the Navy of streptococcal infections occurred with the outbreaks of other respiratory tract diseases of known cause With rare exceptions these outbreaks were limited to the winter and early spring months. Likewise, they occurred mostly in the Northern states where marked daily fluctuations in temperature prevailed between November and May However, there were striking exceptions.

One of these exceptions proved to be of incalculable cost to the health of the Navy. Each summer at Farragut, Idaho there occurred an epidemic outbreak of streptococcal infections. So far as could be determined, these epidemics were initiated in July by the strains of hemolytic streptococcus which had been prevalent on the station during the spring months. (See Chapter II, Figure 3) The month of July, in the mountains of Northern Idaho, brought cool nights and warm, dry days with much wind and dust. Hemolytic streptococcus suddenly became highly infective and spread rapidly from man to man in this environment However, men carrying Farragut strains of hemolytic streptococcus from Northern Idaho to other

points did not initiate streptococcal outbreaks during the summer or fall months. For example, two Farragut carriers of type 19 Re 5 were received at Memphis NATTC in October, 1944. No precautions were taken and yet this organism was not recovered from any other person on the Training Center. Furthermore, other Re strains which may have been carried by Farragut transfers to other stations failed to infect prior to the onset of cold weather in December, 1944.

Small outbreaks of streptococcal infections did occur, however, at two other Training Centers prior to the onset of winter weather. In October, a sulfonamide sensitive type 30 organism gave rise to barrack infections within Camp Callaghan at Sampson Naval Training Center This localized outbreak was induced by a type which had been seeded at this Center for at least one year. At this same time barrack outbreaks occurred in Camps Dahlgren and Decatur of the Great Lakes Naval Training Center These infections were caused by sulfonamide sensitive organisms of type 17 which had been prevalent on this Center during the previous spring months. A few weeks later an outbreak of sulfonamide sensitive type 6 infections occurred in the Negro camp at Bainbridge Naval Training Center This type had likewise been prevalent at this center during the preceding winter.

A striking change in the activity of hemolytic streptococcus occurred throughout the U. S. Navy during the fourth week of December, 1944. At this time, streptococcal outbreaks began in all Naval Training Centers coincident with a rapid spread of respiratory tract diseases from camp to camp within these centers In some instances, the causative agents were sulfonamide sensitive strains of hemolytic streptococcus which had been present but relatively inactive, in other instances, the outbreaks were caused by Re strains of hemolytic streptococcus introduced probably by incoming drafts from Farragut, Idaho.

It was noted that most Naval Activities having a warm, equable climate escaped streptococcal outbreaks at this time However, there were two exceptions: A severe epidemic of type 17 Re 25 infections began during the third week of December in one camp of San Diego Naval Training Center when summer-like weather prevailed The origin of this epidemic could not be determined Coincidentally, another streptococcal outbreak occurred at a Naval Activity in Gulfport, Mississippi This station, with a strength of about 10,000 men, had 266 cases of scarlet fever in a few weeks. Forty-six of these cases occurred among men from Great Lakes within one week after their arrival, and a total of 178 cases occurred in these men and their immediate contacts. This outbreak was caused by the arrival of drafts of Great Lakes men either in the incubation stage of scarlet fever or with acute symptoms

2 *Association of a Filterable Agent:* The possibility of a symbiotic re-

lation between viral and streptococcal activity was recognized. However, it was not practicable to determine the presence or absence of respiratory tract viruses in these large groups of men except by their clinical effects. Most of the streptococcal outbreaks occurred among groups of men having high morbidity rates for measles or for minor, poorly defined, respiratory tract infections. Nevertheless, outbreaks at some of the stations did occur when viral diseases were either absent or unrecognized clinically.

3. *Age of Subjects*: Personnel in recruit training were essentially young men. The age factor in the incidence of streptococcal infections was not subject to analysis under comparable conditions of exposure to hemolytic streptococcus. Training groups in which the average age was thirty years showed a greater tendency to escape streptococcal outbreaks than did training groups with an average age of 21 or less. The highest streptococcal morbidity rates occurred among the youngest recruits.

4. *Time on Station*. It was generally observed that the highest incidence of streptococcal diseases occurred in the training groups and that the morbidity rates for streptococcal infections was usually low among the relatively permanent Ship's Company of a station even when epidemic conditions existed. However, there were striking exceptions in which physicians and nurses had a high incidence of streptococcal infections with the epidemic strains.

5. *"Seasoning" of Personnel*. Explosive outbreaks of streptococcal infections occurred most commonly in the recruit camps where unseasoned men entered training from civilian life. At first, it appeared that lack of "seasoning" was an important factor in the genesis of streptococcal outbreaks. However, more prolonged study showed that in several Training Centers streptococcal epidemics had their origin among men in the Service Schools. Streptococcal morbidity rates in these schools, which were composed of men who had completed recruit training and were presumably "seasoned," reached peaks as high as, or higher than, in the recruit camps. Furthermore, the highest streptococcal morbidity rates ever recorded in the Navy were at the Pre-Radio Schools of Chicago among men who had recently completed recruit training. Moreover, at Norman NATTC, the trainees who had return from overseas had morbidity rates for streptococcal diseases as high as the men who were transferred to Norman from recruit camps. Finally, at Memphis a scarlet fever outbreak occurred among seasoned men who arrived from Great Lakes but did not involve unseasoned recruits coming from civilian life.

6. *Overcrowding*. It was not possible to make controlled observations on this point. Owing to the necessity of training large numbers of men rapidly, barracks were usually overcrowded on most stations. The highest streptococcal morbidity rates occurred in the Pre-Radio Schools of Chicago

and in the Naval Armory at Indianapolis, where overcrowding was marked. However, epidemics of scarlet fever occurred at Madison, Wisconsin, at Del Monte, California, and at San Diego Naval Training Center, where overcrowding did not exist. Furthermore, many overcrowded Activities escaped streptococcal outbreaks

7. *Barracking:* The highest morbidity rates for streptococcal diseases occurred where large numbers of men were barracked together in a gymnasium or armory. However, at Del Monte and at Madison, streptococcal epidemics occurred among men who were barracked in small groups. Controlled studies at Newport (23) suggested that the partitioning of barracks lowered the streptococcal morbidity rates, however, at Farragut the partitioning of barracks proved to be ineffective (24).

8 *Type of Service* It has been shown in Chapter II, Table 3 that personnel aboard ships had low streptococcal morbidity rates in comparison with those at Naval Activities within the continental limits This difference would be even more striking if it were possible to estimate the number of men attached to ships who contracted streptococcal infections ashore. Attention has also been called to the fact that the majority of streptococcal infections ashore were in Training Centers Of the various types of training given in the Navy, radio work seemed to be consistently conducive to the development of streptococcal epidemics Illustrative examples are:

1 The 1942 epidemics of streptococcal infections at Receiving Ship New York (Pier 92) probably originated in and involved chiefly radio men

2 The 1945 outbreak of streptococcal infections at Treasure Island originated in and involved chiefly men in the Radio School

3. The men in the Radio School at Del Monte lived under ideal conditions, nevertheless, there was a streptococcal epidemic in 1945

4. The Navy had four comparable training schools in Chicago during [illegible]

was almost limited to radio men.

6 A small streptococcal epidemic occurred in January 1945, at the Naval Training School in Madison, Wisconsin During December 1944, there were 26 cases of scarlet fever among 2,243 personnel All but one occurred in men attached to the Radio School At this time the scarlet fever morbidity rate per 1000 per year was over 300 among radio men and was only 5 2 in the civilian population of Madison Furthermore, the morbidity rates for all respiratory diseases including scarlet fever was only 26 among Navy V12 men and 0 among Navy men of Armed Forces Institute during December in Madison.

Radio School personnel of Madison were quartered in the University of

Wisconsin dormitories, three or four in a room, and in the University Stadium, eight to twenty-four in a room. The radio men who contracted scarlet fever had been barracked in six separate buildings. They all came from the Great Lakes Naval Training Center, but from nine different camps As all radio men, they had long hours of indoor class room work and close contact outside of their sleeping quarters

In contrast to the high incidence of streptococcal infections among men receiving training in radio, there appeared to be a strikingly low incidence of streptococcal infections among dental personnel working in dispensaries during periods of streptococcal epidemics when both the morbidity and carrier rates for hemolytic streptococcus were high. One example will illustrate this point. During the 1945 epidemic of scarlet fever at San Diego Naval Training Station, there were 744 medical and dental personnel attached to the Medical Department. There were no cases of scarlet fever in a small group of 18 nurses and 68 WAVES. One of 25 medical officers and eight of 259 medical hospital corpsmen contracted scarlet fever. Only one of 209 enlisted dental personnel and none of the 165 dental officers, who treated an average of 950 men per day during the severe 1945 epidemic at San Diego, contracted scarlet fever.

9. *Rate of Change of Population* So far as could be determined, no airborne streptococcal epidemic originated in the fixed personnel of a Naval Activity. At Training Centers the Ship's Company contracted streptococcal infections, however, morbidity rates among these personnel were consistently lower than the rates prevalent among trainees. Furthermore, the highest morbidity rates in the Navy occurred in training Activities with the shortest training period and the most rapid turnover of men. These observations are in accord with the opinion of Dudley (22).

10. *Carrier Rates* It is commonly believed that streptococcal outbreaks occur only when the throat carrier rate is high However, this concept stems in most instances from the fact that carrier rates for hemolytic streptococcus have been determined after an epidemic has been initiated. The observations made at Naval Activities are in accord with the finding that streptococcal carrier rates are ordinarily high during an epidemic. However, the initiation of epidemics has been observed frequently when carrier rates and morbidity rates were low For example, it has been pointed out that at Norman an epidemic occurred when the carrier rate was consistently low (5%). Furthermore, at Memphis an epidemic was confined to a group of radio men when the carrier rate was moderately high (25%) in other groups on the station Finally, the majority of streptococcal epidemics in the Navy followed the introduction of an epidemic strain which had not been detected in either high or low carrier rate groups.

B THE CRITICAL FACTOR—EXPOSURE TO A HIGHLY COMMUNICABLE STRAIN OF HEMOLYTIC STREPTOCOCCUS

The initiation of streptococcal epidemics was not limited to any location, to seasonal conditions, to stations having virus diseases of the respiratory tract, to younger age groups, to "unseasoned" men, to overcrowded Naval Activities where large numbers of men were barracked together, to any one type of training nor to the presence of high streptococcal carrier rates Some of these influences conditioned the outbreak of streptococcal diseases. The most important of these conditioning factors seemed to be the rapidity with which classes of trainees turned over. It was the movement of men that appeared to be, with perhaps a single exception, essential to the genesis of a streptococcal epidemic. This observation was in accord with the concept of Dudley, who pointed out: "Therefore, other things being equal, in those communities where the number of inhabitants remains practically constant, the relative incidence of disease (respiratory) will be inversely proportional to the average duration of residence, or some function of it"

The number of inhabitants of many Naval Activities remained almost constant during the last year of World War II. However, *other things were not equal* and there were marked differences in the incidence of streptococcal diseases For example, stations where men received training for the Marine Corps or for Naval Aviation escaped streptococcal epidemics and had relatively low streptococcal morbidity rates irrespective of their duration of residence Naval Centers which trained recruits and Naval Activities which received drafts of trained recruits had streptococcal epidemics irrespective of whether the duration of residence was less than one month or greater than three months. Two factors which varied frequently were the degree of exposure to respiratory tract infections and the character of the infectious agents The importance of these two factors was indicated by the observations recorded: (a) Men arriving from civilian life became infected after arrival at a station with strains of hemolytic streptococcus which were prevalent on the station, (b) there was a high degree of exposure in the dispensaries and scarlet fever wards, (c) when exposure to certain strains occurred on a station the morbidity rates rose rapidly, (d) when these strains were carried during the winter months to other Naval Activities epidemics occurred among the men in contact with newly arrived drafts.

Exposure to highly communicable strains of hemolytic streptococcus appeared to be the critical factor in the origin of most streptococcal epidemics in the Navy occurring during the last year of World War II These strains, which were not detected prior to the onset of an epidemic, were re-

sponsible for 80 to 100% of infections during each outbreak of streptococcal diseases. The following are illustrative examples:

1. *Wright Junior College* had had sporadic infections with sensitive strains of type 17. The induction of a new class from a Training Center was followed by a streptococcal outbreak caused by strains type 17 Re 25. One month later, the induction of another class was followed by an outbreak of type 19 Re 25

2. *Manley School* had had sporadic infections with sensitive strains of types 19, 17 and 3. The induction of a new class from Training Centers was followed by an outbreak caused by type 3 Re 5. One month later, the induction of another class was followed by an outbreak of type 17 Re 125.

3. *Herzl School* had had sporadic infections with sensitive strains of type 19, 17 and 3 The induction of a new class from Training Centers was followed by an outbreak caused by type 19 Re 25

4. *Great Lakes Naval Training Center* had had sporadic infections with sulfonamide sensitive organisms, particularly types 17 and 19. The onset of an epidemic outbreak followed the appearance of Re strains. In camps Mahan, Maury and Downes, streptococcal outbreaks were caused by type 3 Re 5. Prior to this, no type 3 organisms had been recovered in this camp. Likewise in camp McDonough, an outbreak was caused by type 17 Re 25. Prior to this no type 17 had been recovered in this camp

5 *Sampson Naval Training Center* had had sporadic infections caused by sulfonamide sensitive types 30 and many other Group A hemolytic streptococci An epidemic began in the Service School camp and spread to other camps This epidemic was caused by type 19 Re 1 or Re 5 Prior to this, type 19 had been conspicuously rare and these few organisms were sulfonamide sensitive.

6 *Bainbridge Naval Training Center* had had sporadic infections with sulfonamide sensitive type 6 and many other types. Streptococcal outbreaks began in the Service Schools and spread to recruit camps. These outbreaks were initiated by Re strains of types 17, 19 and 3 which had not been detected prior to the epidemic

7. *San Diego Naval Training Center* had been free of clinically recognized streptococcal infections when a severe epidemic occurred in one camp. This was caused by type 17 Re 25.

8. *Norman NATTC* had had sporadic infections caused by several sulfonamide sensitive types. An epidemic was initiated by types 17 Re 125 and type 3 Re 5 and maintained by type 19 Re 1

9. *Memphis NATTC* had had sporadic infections caused by several sulfonamide sensitive types when an epidemic occurred among the radio men. This outbreak was caused by type 17 Re 125.

C. CHARACTERISTICS OF THE EPIDEMIC ORGANISMS

A relatively few epidemic organisms appeared to cause the large majority of war time streptococcal infections in the U. S. Navy. During the last two years of the World War II more than 50% of the organisms identified were of types 19 and 17. The typing results for the winter of 1944 were presented in Chapter V, Table 1. The findings between October 1944 and June, 1945 are shown here in Table 1. In both the 1944 series of 4,560 cultures and in the 1944–45 series of 16,771 cultures, between 95% and 97% of the organisms identified were of ten types The distribution of serologic types in the Continental Navy for these two years is shown in Tables 2a and 2b

It is seen in these tables that all but one of the prevalent types maintained their prominence throughout this period of study Type 18 in the 1944 series was replaced by type 44 in the 1945 series However, the distribution of types changed at many Training Centers For example, at Bainbridge, types 19 and 18 were predominant in 1944 and types 17 and 6 in 1945; type 24 which was inconspicuous in 1944 became prevalent in 1945 At Farragut, types 19, 17, 1 and 3 were the most prevalent organisms during both years At Great Lakes, types 19, 17 and 3 were prevalent both in 1944 and 1945, however, type 5, which had been prevalent in 1944 became inconspicuous in 1945. At Sampson, type 19, which had been inconspicuous in 1944, became the predominant type in 1945 Similar observations were made at other Training Activities where it seemed that the rise of a type to predominance was associated with the introduction of one or more epidemic strains

These strains had two common characteristics: *communicability*, the capacity to grow readily when transplanted to the upper respiratory tract of man, and *pathogenicity*, the capacity to produce disease in man These two characteristics were independent of the serologic type, of sensitivity to sulfonamides and of the production of erythrogenic toxin They all formed matt colonies on blood agar plates and probably produced Lancefield's "M substance" and perhaps other important products which have not yet been defined Some of these strains of types 19 and 17 caused a high incidence of scarlet fever These strains also appeared to induce rheumatic fever Other strains of these two types and many other prevalent types caused streptococcal throat infections with relatively little scarlatina or rheumatic fever In one instance a strain of type 17 showed extraordinary capacity to spread rapidly in the warm, equable climate of San Diego, California Studies were made at Farragut to determine whether prevalent strains differed in their ability to resist solar radiation and heat The findings were.

1 *Observations on Solar Sterilization of Mattresses*· Two experiments in-

TABLE 1

Streptococcal Types in 18,941 Throat Cultures Examined October 1944–June 1945

Station	Serological Types of Hemolytic Streptococcus																									
	1	2	3	4	5	6	8	9	11	12	14	17	18	19	24	26	28	29	30	33	36	41	42	44	NCT*	Not At	Total Rec'd
Bainbridge	93		314	2	13	762	2		4	33	7	956	18	626	511			1	29		3	1	1	43	632	333	4217
Boston	4		4							1		19	1	10	2				6						9	23	75
Chicago	84		311		46	118				74	8	656	12	506	43		2		53		20			11	227	71	2269
Corona	4		10		3	8				4		42		29	7				3		4			3	31	43	208
Farragut NTC	168		326	5	6	100				26	3	613	1	626	75				3		34			5	264	403	2149
Farragut Hosp	3		15							1		13		33											1	8	74
Great Lakes	17		330		29	90	2			10		586		200	44				4	1	2			11	130	96	1599
La Jolla										29																1	30
Long Beach			6		3							5		22	2						1	1			6	4	58
Memphis	18		2			32				15	1	77	4	38	2		2		2		1			7	43	12	249
Norman	38		158		13	102				23		242	7	283	67				22		37	1		6	145	104	1205
Pearl Harbor					18	1				3		1		8					7					1	2	19	63
Sampson	133	9	382		68	135		1	2	47	18	92	14	540	53	1			261		16			81	343	249	2636
San Diego	3		28		8	5				3		417		64	3				6					2	19	105	658
Seattle	130		20		1	5				7		31	4	54	7				8		10			1	23	68	390
Treasure Is	8		77	1	4	9				6	1	160	3	142	18				19		1	1		1	45	65	677
Totals	681	9	1999	8	198	1338	4	1	8	238	41	3765	66	3230	812	1	5	1	418	1	121	4	2	170	1925	1837	18,771

* Not a common type † Serological group other than A

volving the exposure of Group A beta hemolytic streptococci to the direct rays of the summer sun were made In each experiment, three strains of streptococci were used; i.e., type 3, no sulfonamide resistance, type 17, no

TABLE 2a

Distribution of Ten Most Prevalent Types of Hemolytic Streptococcus Identified in Throat Cultures, January–July 1944

Serological Type	Number of Cultures	% Cultures
19	955	35
17	588	22
1	294	11
3	235	9
5	161	6
6	121	4 5
18	104	4
12	90	3
24	85	3
30	67	2 5
Total	2700	100

TABLE 2b

Distribution of Ten Most Prevalent Types of Hemolytic Streptococcus Identified in Throat Cultures, October 1944–June 1945

Serologic Type	Number of Cultures	% Cultures
17	3,765	29
19	3,259	25
3	1,999	15 5
6	1,338	10 5
24	812	6 5
1	691	5 5
30	412	3
12	288	2
5	198	1 5
44	170	1 5
Total	12,932	100

sulfonamide resistance and type 17 with a sulfonamide resistance of 125 mg %. Suspensions of each of these strains were sprayed lightly over the surface of glass Petri dishes arranged in three series, one series for each of the strains. The sprayed, uncovered dishes were placed immediately on the surface of mattresses exposed to direct sunlight. Temperature readings

were taken from thermometers lying on the surface of the mattresses. These readings were assumed to be approximately the temperatures of the Petri dishes. Temperature readings were also taken from thermometers hung in the shade and in the direct rays of the sun. Dishes were removed from the mattresses from time to time and pour plates made. The shortest exposure was 15 minutes and the longest was 3 hours In all cases, streptococci of the three strains used in these experiments survived in numbers

TABLE 3a

Growth of Two Strains of Group A Beta Hemolytic Streptococci after Spraying onto a Glass Surface, Drying Thereon for a Period of Twenty-four Hours and Then Exposing to Various Experimental Temperatures in a Hot Air Oven

Time Exposed (Hours)	Type 14 Re 0			Type 19 Re 25		
	Experimental Temperatures (Degrees Cent)					
	56	65	85	56	65	85
Control	TNTC*	TNTC	TNTC	TNTC	TNTC	TNTC
25	TNTC	TNTC	++	TNTC	TNTC	TNTC
50	TNTC	TNTC	++	TNTC	TNTC	TNTC
75	TNTC	TNTC	++	TNTC	TNTC	++++
1 00	TNTC	TNTC	0	TNTC	TNTC	+++
1 50	TNTC	TNTC	+	TNTC	TNTC	+++
2 00	TNTC	TNTC	0	TNTC	TNTC	++
2 50	TNTC	TNTC	0	TNTC	TNTC	+
3 00	TNTC	TNTC	0	TNTC	TNTC	+
4 00	TNTC	TNTC	0	TNTC	TNTC	0

* TNTC Colonies of beta hemolytic streptococci too numerous to count

too numerous to count The average mean temperatures (degrees centigrade) prevailing during the experiment were:

	Exp 10-4-45	Exp 10-9-45
Surface of Mattresses	30 1	32 7
Air in the Shade	18 0	20 0
Air in Direct Sunlight	33 1	30 6

Under these conditions hemolytic streptococcus appeared to be unaffected. Further experiments in which the exposure was more severe showed that only type 17 Re 125 was unaffected by solar radiation. These observations are reported in Chapter XVI, page 153.

2. *Relationship of Temperature to Survival of Beta Hemolytic Streptococci:* Five dried cultures of Group A beta hemolytic streptococci (A-3 Re 0, A-17

incubation at 37°C., were able to produce colonies too numerous to count. In addition, strains A-24 Re 0 and A-19 Re 25 were able to produce similar results at a temperature of 65°C. At 85°C. all strains tested were affected, after varying periods of exposure, except the sulfonamide resistant strain A-17 Re 125. This strain, type 17 with a sulfonamide resistance of 125, was able to withstand the temperature of 85°C. and after incubation, to produce colonies of beta hemolytic streptococci too numerous to count. These findings are shown in Tables 3a and 3b

TABLE 3b

Growth of Three Strains of Group A Beta Hemolytic Streptococci after Spraying onto a Glass Surface, Drying Thereon for a Period of Either Twenty-Four or Forty-Eight Hours and Then Exposing to Various Experimental Temperatures in a Hot Air Oven

Time Exposed (Hours)	Strain Type 3 Re 0			Strain Type 17 Re 0			Strain Type 17 Re 125		
	Experimental Temperatures (Degrees Cent)								
	51	56	85	51	56	85	51	56	85
Control	TNTC*	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC
25	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC
50	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC
75	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC
1 00	TNTC	TNTC	TNTC	TNTC	TNTC	++	TNTC	TNTC	TNTC
1 50	TNTC	TNTC	TNTC	TNTC	TNTC	++	TNTC	TNTC	TNTC
2 00	TNTC	TNTC	TNTC	TNTC	TNTC	++++	TNTC	TNTC	TNTC
2 50	TNTC	TNTC	++++	TNTC	TNTC	++	TNTC	TNTC	TNTC
3 00	TNTC	TNTC	+	TNTC	TNTC	+++	TNTC	TNTC	TNTC
4 00	TNTC	TNTC	0	TNTC	TNTC	++	TNTC	TNTC	TNTC

* TNTC Colonies of beta hemolytic streptococci too numerous to count

In brief, there was clinical evidence of important strain differences in the prevalent types of hemolytic streptococcus. Most of these differences in capacity to cause disease were not subject to analysis in the laboratory. One difference, the capacity to withstand solar radiation and heat was shown experimentally It appeared that one or more strains of type 17 were unusual in resistance to sunlight and high temperatures. This may have been a significant contributing factor in the streptococcal outbreak which occurred at the San Diego Naval Training Center

SUMMARY

Navy statistics showed that hemolytic streptococcus was usually inactive in locations and seasons having a warm, equable climate There were exceptions, however For example, strains of hemolytic streptococcus sud-

were taken from thermometers lying on the surface of the mattresses. These readings were assumed to be approximately the temperatures of the Petri dishes Temperature readings were also taken from thermometers hung in the shade and in the direct rays of the sun. Dishes were removed from the mattresses from time to time and pour plates made. The shortest exposure was 15 minutes and the longest was 3 hours. In all cases, streptococci of the three strains used in these experiments survived in numbers

TABLE 3a

Growth of Two Strains of Group A Beta Hemolytic Streptococci after Spraying onto a Glass Surface, Drying Thereon for a Period of Twenty-four Hours and Then Exposing to Various Experimental Temperatures in a Hot Air Oven

Time Exposed (Hours)	Type 24 Re 0			Type 19 Re 25		
	Experimental Temperatures (Degrees Cent)					
	56	65	85	56	65	85
Control	TNTC*	TNTC	TNTC	TNTC	TNTC	TNTC
25	TNTC	TNTC	++	TNTC	TNTC	TNTC
50	TNTC	TNTC	++	TNTC	TNTC	TNTC
75	TNTC	TNTC	++	TNTC	TNTC	++++
1 00	TNTC	TNTC	0	TNTC	TNTC	+++
1 50	TNTC	TNTC	+	TNTC	TNTC	+++
2 00	TNTC	TNTC	0	TNTC	TNTC	++
2 50	TNTC	TNTC	0	TNTC	TNTC	+
3 00	TNTC	TNTC	0	TNTC	TNTC	+
4 00	TNTC	TNTC	0	TNTC	TNTC	0

* TNTC Colonies of beta hemolytic streptococci too numerous to count

too numerous to count The average mean temperatures (degrees centigrade) prevailing during the experiment were:

	Exp 10-4-45	Exp 10-9-45
Surface of Mattresses	30 1	32 7
Air in the Shade	18 0	20 0
Air in Direct Sunlight	33 1	30 6

Under these conditions hemolytic streptococcus appeared to be unaffected Further experiments in which the exposure was more severe showed that only type 17 Re 125 was unaffected by solar radiation These observations are reported in Chapter XVI, page 153

2. *Relationship of Temperature to Survival of Beta Hemolytic Streptococci:* Five dried cultures of Group A beta hemolytic streptococci (A-3 Re 0, A-17 Re 0, A-17 Re 125, A-24 Re 0 and A-19 Re 25) were exposed to several experimental temperatures for varying periods of time. All strains tested were able to withstand a temperature of 56°C for four hours and after subsequent

CHAPTER XIV

OBSERVATIONS ON STREPTOCOCCUS HEMOLYTICUS AS A DUST CONTAMINANT AT FARRAGUT NAVAL TRAINING CENTER

These studies were made between February and August, 1945. At this time recruit training had been discontinued at Farragut, Idaho Most of the barracks had been "secured" (cleaned and locked) between November, 1944 and February, 1945. Cultures from various buildings were classified as either "not secured" or "secured" (closed). The cultures classified as "not secured" were taken at regular intervals during the eight-month period of this study. The cultures from barracks "secured" for more than four months were taken during a season of the year considered relatively unfavorable to the activity of hemolytic streptococcus. Two methods were used for collecting dust samples during this study By the first method it was possible to make quantitative determinations but only from a composite sample of dust. By the second method it was possible to collect samples from many parts of an area and to identify more than one type of hemolytic streptococcus in a single area. The second method was adopted for most of this study because it saved time and was effective A description and analysis of these two methods is given in Chapter XIX.

A. THE SURVIVAL TIME OF HEMOLYTIC STREPTOCOCCUS IN DUST

This study was made to determine whether contamination of floor dust persisted in buildings which had been cleaned and secured A total of 1,406 cultures were made There were 159 cultures (11 3%) positive for Group A, 66 cultures (4.7%) positive for other groups of beta hemolytic streptococcus and 1,181 cultures (84%) were negative. Among the Group A organisms, type 17 was recovered in 41 cultures (2 9%) type 19 in 33

number of cultures the percentage of positive cultures obtained from month to month was generally constant. This Table also shows that the degree of contamination in the "secured" areas was almost as great as in areas not "secured" and that Group A hemolytic streptococcus survived in floor dust for eight months at Farragut, Idaho.

denly acquired tremendous activity during the mid-summer in the North at Farragut, Idaho. Furthermore, epidemics occurred during mild winter months in the sunny cities of San Diego and Gulfport. Whatever may be the effect of climate on the activity of hemolytic streptococcus, this did not appear to be the only important factor in the initiation or in the prevention of streptococcal epidemics.

The presence of viral, respiratory tract infections may have predisposed, either directly or indirectly, to streptococcal infections. However, this did not seem to be a critical factor in the initiation of streptococcal epidemics.

The highest incidence of streptococcal infections occurred in the youngest age groups. However, it was not possible to evaluate the factor of the age of the host under controlled conditions.

Fixed personnel were susceptible to streptococcal infections but in general conditions among these groups were unfavorable to the genesis of an epidemic.

A majority of the Navy's streptococcal infections occurred during recruit training. However, many streptococcal epidemics originated and were most severe at training Activities where the personnel had recently completed training. There was no indication that the degree of "seasoning" was an important factor in the pathogenesis of streptococcal diseases.

Overcrowding may well have been a contributing factor but did not appear to be a critical factor in the genesis of streptococcal epidemics.

The barracking of large numbers of men together may well have been a contributing factor but not a critical factor in initiating streptococcal epidemics.

The type of service performed in the Navy appeared to influence the risk of streptococcal infections Dental officers and their assistants, for reasons unknown, seemed to escape the prevalent infections. In contrast, some condition associated with radio training appeared to be a contributing factor in initiating streptococcal epidemics. This may well have been due to the fact that equipment was used by many men without being disinfected

The throat carrier rate prior to the onset of a streptococcal epidemic did not appear to be a significant factor in its genesis.

The rate of change of population appeared to be intimately associated with the genesis of streptococcal outbreaks and the maintenance of high morbidity rates.

At Naval Activities with rapidly changing personnel the initiation of streptococcal outbreaks seemed to be determined by exposure to highly communicable, pathogenic strains of hemolytic streptococcus.

[illegible] factor in the relation between infectious agent and

TABLE 2

Dust Contamination in Five Areas

Activity	Type 17		Type 19		Other A		Not A		Cultures Negative	
	No Pos	% Pos	No Pos	% Pos	No Pos	% Pos.	No Pos	% Pos	No Neg	% Neg
Central Administration Building	1	1.2	2	2.3	7	8.8	9	11.3	61	76.2
Station Personnel Service Buildings	—	—	—	—	—	—	—	—	6	100
Station Personnel Barracks*	—	—	—	—	1	2.7	4	10.8	32	86.5
Station Personnel Barracks	—	—	—	—	—	—	—	—	37	100
Station Personnel Medical Dispensaries*	—	—	1	3.4	—	—	2	6.9	26	89.7
Prisoner of War Barracks*	—	—	—	—	—	—	—	—	6	100
Prisoner of War Medical Dispensary	1	3.7	—	—	3	11.1	—	—	23	85.2
Recruit Barracks*	1	0.9	—	—	7	6.0	7	6.0	101	87.1
Recruit Barracks	4	2.5	1	0.6	10	6.2	10	6.2	136	81.5
Recruit Service Buildings*	—	—	1	12.5	—	—	—	—	7	87.5
Recruit Service Buildings	—	—	1	1.7	5	8.7	2	3.4	50	86.2
Recruit Medical Dispensaries*	13	7.3	10	5.0	16	8.9	7	3.9	133	74.3
Mattresses—stored	4	1.1	2	0.5	7	1.8	7	1.8	361	94.8
Pillows—stored	—	—	—	—	1	14.3	—	—	6	85.7
Advanced Training Barracks (Gilmore)*	2	3.8	1	1.9	4	7.5	2	3.8	44	83.0
Advanced Training Barracks	1	2.2	3	6.5	5	10.9	7	15.2	30	65.2
Advanced Training Service Buildings*	—	—	—	—	3	11.1	3	11.1	21	77.8
Advanced Training Medical Dispensary	7	11.8	4	6.8	9	15.3	2	3.4	37	62.7
Naval Hospital Scarlet Fever Ward	4	18.4	3	13.5	1	4.5	1	4.5	13	59.1
Naval Hospital Corps School	3	5.2	4	7.2	4	7.2	2	3.6	43	76.8
Total	41	2.9	33	2.3	85	6.1	66	4.7	1181	81.0

* Floors cleaned

B. THE DEGREE OF DUST CONTAMINATION IN FIVE AREAS

Dust cultures were made in five areas of Farragut. At this time the recruit area had been closed and most of the buildings were secured. The findings are shown in Table 2.

TABLE 1

Dust Contamination—Effect of Environment and Time

Status of Activity	Percentage of Cultures Positive							
	Type 17		Type 19		Other A		Not A	
	No Pos.	% Pos	No Pos	% Pos	No Pos	% Pos.	No Pos	% Pos.
Not Secured (in use)	22	3 5	19	3 0	46	7.4	44	7.1
Secured 1-30 days	—	—	—	—	4	3.5	5	4 4
Secured 1-2 months	—	—	—	—	—	—	2	5 0
Secured 2-3 months	2	1 8	4	3 5	16	13.9	9	7 8
Secured 3-4 months	5	4 3	2	1.7	7	5.9	3	2 5
Secured 4-5 months .	4	1 9	3	1.5	3	1.5	1	0 5
Secured 5-6 months	2	2.1	2	2 1	6	6 3	1	1 0
Secured 6-7 months	4	25 0	2	12.5	2	12.5	1	6 2
Secured 7-8 months	1	2.9	1	2 9	1	2 9	—	—
Secured 8-9 months	1	2 0	—	—	—	—	—	—
Total . .	41	2 9	33	2 3	85	6.1	66	4.7

Table 2 shows the distribution of streptococcal contamination in the following areas:

1. *The Station Personnel Area:* The greatest degree of contamination of floor dust occurred in the Central Administration Building where recruits, members of the Service Schools and Outgoing Units had gathered each day. Floor dust in the dispensary was not heavily contaminated. The use of this dispensary was limited to fixed station personnel among whom the incidence of streptococcal infections was low.

2. *Recruit Area* Dust samples were collected only from buildings which, though used in the past by recruits, had been secured for several months. Nevertheless, the floor dust in all of these buildings was contaminated with hemolytic streptococcus The highest degree of contamination occurred in the dispensaries. Hemolytic streptococci were also recovered from one pillow and mattresses which had been used in the dispensaries and then aired and stored in a secured recruit dispensary.

3 *Naval Hospital* Samples of floor dust were taken from a scarlet fever ward and the school used for training corpsmen. At this time the number of cases of scarlet fever had reached the lowest level in the history of Farragut. Men from the Hospital Corps School worked on all of the wards at

TABLE 2

Dust Contamination in Five Areas

Activity	Type 17		Type 19		Other A		Not A		Cultures Negative	
	No Pos	% Pos	No Pos	% Pos	No Pos	% Pos	No. Pos	% Pos	No Neg	% Neg
Central Administration Building	1	1.2	2	2.5	7	8.8	9	11.3	61	76.2
Station Personnel Service Buildings	—	—	—	—	—	—	—	—	6	100
Station Personnel Barracks*	—	—	—	—	1	2.7	4	10.8	32	86.5
Station Personnel Barracks	—	—	—	—	—	—	—	—	37	100
Station Personnel Medical Dispensaries*	—	—	1	3.4	—	—	2	6.9	26	89.7
Prisoner of War Barracks*	—	—	—	—	—	—	—	—	6	100
Prisoner of War Medical Dispensary	1	3.7	—	—	3	11.1	—	—	23	85.2
Recruit Barracks*	1	0.9	—	—	7	6.0	7	6.0	101	87.1
Recruit Barracks	4	2.5	1	0.6	10	6.2	10	6.2	136	84.5
Recruit Service Buildings*	—	—	1	12.5	—	—	—	—	7	87.5
Recruit Service Buildings	—	—	1	1.7	5	8.7	2	3.4	50	86.2
Recruit Medical Dispensaries*	13	7.3	10	5.6	16	8.9	7	3.9	133	74.3
Mattresses—stored	4	1.1	2	0.5	7	1.8	7	1.8	361	94.8
Pillows—stored	—	—	—	—	1	14.3	—	—	6	85.7
Advanced Training Barracks (Gilmore)*	2	3.8	1	1.9	4	7.5	2	3.8	44	83.0
Advanced Training Barracks	1	2.2	3	6.5	5	10.9	7	15.2	30	65.2
Advanced Training Service Buildings*	—	—	—	—	3	11.1	3	11.1	21	77.8
Advanced Training Medical Dispensary	7	11.8	4	6.8	9	15.3	2	3.4	37	62.7
Naval Hospital Scarlet Fever Ward	4	18.4	3	13.5	1	4.5	1	4.5	13	59.1
Naval Hospital Corps School	3	5.2	4	7.2	4	7.2	2	3.6	43	76.8
Total	41	2.9	33	2.3	85	6.1	66	4.7	1181	84.0

* Floors cleaned

the Naval Hospital. The floor dust of this school was heavily contaminated with Group A hemolytic streptococcus. The highest degree of contamination occurred in the scarlet fever ward even though there were few scarlet fever patients when these samples were taken.

4. *The Advanced Training and Overflow Area:* This area was used both by men receiving advanced training at Farragut and by men who had completed training at several Centers and were sent to Farragut to await transfer to another Naval Activity. Barrack floor dust was contaminated. The highest degree of streptococcal contamination of floor dust occurred in the dispensary.

5. *Prisoner of War Area:* Only a few cultures were taken from this isolated area. There was streptococcal contamination of the floor dust in the dispensary.

C. CONTAMINATION OF BEDDING AMONG NAVY PRISONERS

A draft of prisoners was transferred to Farragut from Bremerton, Washington. At Bremerton there had been overcrowding and a high incidence of streptococcal diseases among these men. On arrival at Farragut the prisoners were divided into two groups. Group 1 was placed in the "Brig" where crowding existed. Group 2 was confined to two barracks in Camp Scott where there was no crowding. Cultures were made of the throats, mattress covers and blankets of these two groups of prisoners.

Group 1: There were 167 men in this group; 42 of them had had streptococcal infections within the previous month. The occurrence of positive Group A cultures was:

Throat, mattress cover, blanket	10
Throat, mattress cover	19
Throat, blanket	13
Mattress cover, blanket	4
No correlation	69

Group 2: There were 22 men in this group. Thirteen of them had had streptococcal diseases within the previous month. The occurrence of positive Group A cultures was:

Throat, mattress cover, blanket	0
Throat, mattress cover	1
Throat, blanket	0
Mattress cover, blanket	1
No correlation	20

Throat carrier rates in both of these groups was high. The cause for the greater degree of contamination of bedding in Group 1 remained unexplained.

D CONTAMINATION OF BEDDING AMONG PRISONERS OF WAR

A group of 700 German prisoners was quartered under isolation conditions just outside of the Training Center. These men had many upper respiratory tract diseases Two men had scarlet fever within one week after arrival However, the incidence of streptococcal infections remained at a low level Cultures of their throats and bedding were made when respiratory diseases were prevalent. Although these men lived in crowded conditions, the throat streptococcal carrier rate remained low. Among 249 men only 28 carried Group A hemolytic streptococcus in their throat flora Among 249 mattress covers and 247 blankets, only six of each gave cultures positive for Group A hemolytic streptococcus. No type 17 organisms and no sulfonamide resistant organisms were recovered among these German prisoners.

E CONTAMINATION OF BEDDING AMONG MEN IN AN OVERFLOW UNIT

The men had returned from overseas and were awaiting discharge. They lived leisurely in quarters free of overcrowding and had little contact with other personnel on the station A streptococcal survey was made of 90 men in this unit. Group A hemolytic streptococcus was recovered from 23 throats, from eight of 90 mattress covers and four of 90 blankets. Although the throat carrier rate was moderately high there was little contamination of bedding

Throat, mattress cover, blanket	No positive cultures
Throat, mattress cover	1
Throat, blanket	1
Blanket, mattress cover	2
No correlation	86

These findings were similar to the findings among the prisoners of war However, the infectious agents were different. Type 17 Re 125 was recovered from ten men and type 19 Re 25 from three men in this Unit. Nevertheless, the incidence of streptococcal diseases and the contamination of bedding was negligible.

F. CONTAMINATION OF BEDDING AMONG MEN IN OUTGOING UNITS OF SERVICE SCHOOLS AND RECRUIT CAMPS

Surveys were made on these two groups when both recruit and advanced training were being discontinued at Farragut There was no overcrowding and the incidence of respiratory diseases had fallen to a minimum Nose, throat and blanket cultures were made in 50 men in the Service School Outgoing Unit and in 100 men in Recruit Camp Outgoing Unit The findings are shown in Tables 3a and 3b

Contamination of blankets in these two groups occurred only to a moderate degree irrespective of recent streptococcal infections. There were negative blanket cultures for 11 nasal carriers of Group A hemolytic streptococcus.

Positive—Nose, throat, blanket	6
Positive—Nose, throat	8
Positive—Nose, blanket	0
Positive—Throat, blanket	8

TABLE 3a

Cultures from Service School—Outgoing Unit

Nose					Throat					Blanket				
Type 17	Type 19	Other A	Not A	Neg	Type 17	Type 19	Other A	Not A	Neg	Type 17	Type 19	Other A	Not A	Neg
Streptococcal Disease During the Past Month														
				17			3	2	12				1	16
No Streptococcal Disease During Past Month														
		1		32	3	2	6	3	19	2	1		2	23

TABLE 3b

Cultures from Recruit Camp—Outgoing Unit

Nose					Throat					Blanket				
Type 17	Type 19	Other A	Not A	Neg	Type 17	Type 19	Other A	Not A	Neg	Type 17	Type 19	Other A	Not A	Neg
Streptococcal Disease During Past Month														
		1		23		2	6	1	15	2	3	11		8
No Streptococcal Disease During Past Month														
1	1	7		67	2	5	20	3	46	4	8	21	3	37

G. CONTAMINATION OF BLANKETS IN SEVERAL LOCATIONS

Cultures were made of blanket dust during the summer months of 1945. There were no recruits, no crowding and few streptococcal infections at this time; nevertheless, positive cultures for Group A hemolytic streptococcus were obtained in 18% of respiratory disease ward blankets, in 10% of general ward blankets and in 4% of the barrack blankets. In the barracks some of the blankets had been in use for less than one week and others

for over one year. The incidence of contamination was independent of the time of use These observations are shown in Table 4

H CONTAMINATION OF COATS

Cultures were taken from the throats and coats of the last group of recruits to leave Farragut. These men were trained at Farragut when the Center's complement was small. There was no overcrowding Three of these men had hemolytic streptococcus in their throat flora and on their

TABLE 4

Blanket Dust Survey—June to October, 1945

Length of Time Since Cleaned	In Barracks					In Dispensary					Ward				
	West Coast Overflow Unit					Respiratory Disease Ward					General Ward				
	Type 17	Type 19	Other A	Not A	Neg	Type 17	Type 19	Other A	Not A	Neg	Type 17	Type 19	Other A	Not A	Neg
1-7 days	—	—	1	1	15	4	11	5	6	103	3	—	3	7	81
8-30 days	2	—	2	5	108	1	2	1	4	30	3	—	4	6	52
31-60 days	—	—	2	6	84	—	—	—	—	—	—	—	—	1	—
61-90 days	2	—	1	2	123	—	—	—	—	—	—	—	—	—	—
91 days-6 mos	1	2	—	3	106	—	—	—	—	—	—	—	—	—	—
7 mos -1 yr	2	—	—	2	35	—	—	—	—	—	—	—	—	—	—
Over 1 year	—	—	1	—	4	—	—	—	—	—	—	—	—	—	—
Total	7	2	7	19	475	5	13	6	10	133	6	none	7	14	133

TABLE 5

Pea Coat Survey

Throat					Pea Coat				
Type 17	Type 19	Other A	Not A	Neg	Type 17	Type 19	Other A	Not A	Neg
1	4	13	3	16		3	2		32

coats In two instances the serologic type of hemolytic streptococcus was the same as the type recovered from the throat The findings are shown in Table 5

I. CONTAMINATION IN A DISPENSARY WARD

This survey was made of 68 patients in a ward dispensary at a time when the incidence of streptococcal infections had fallen to a low level The patients in this dispensary had either streptococcal infections or other medical or surgical diseases Each man was given a freshly laundered

blanket on admission. Since the weather was warm, this blanket remained at the foot of the bed in most instances. Throat cultures were made when the patients were admitted. Cultures of bed clothing were made 48 hours later to determine the extent of contamination.

TABLE 6

Contamination of Bedding among Personnel in Sick Bay with Streptococcal and Non-Streptococcal Diseases

	Number	Percent
Throat, sheet, mattress cover, mattress, blanket (complete correlation)	4	10 0
Throat, sheet, mattress cover, mattress	2	5 0
Throat, sheet, mattress cover	1	2.5
Throat, sheet	4	10 0
Throat, sheet, blanket	1	2 5
Throat, mattress	1	2 5
Throat, sheet, mattress, blanket	2	5 0
Throat, blanket	5	12 5
Throat, mattress cover, mattress	1	2 5
Throat, mattress cover, blanket	2	5 0
Throat, sheet, mattress cover, blanket	1	2 5
No Correlation	16	40 0
Total	40	100

TABLE 7

The Distribution of Types among Men and Their Bedding

Cultures Taken from	Serological Typing					Total
	17	19	Other A	Not A	Negative	
Throat	26	7	26	9	0	68
Sheet	16	6	14	3	25	64
Mattress Cover	10	4	8	0	42	64
Mattress	9	3	8	3	44	67
Blanket	10	8	8	6	14	46

Group A hemolytic streptococci were recovered from 87 1% of the throat cultures, 56 5% of the blankets, 56.2% of the sheets, 34 4% of mattress covers and 29 9% of the mattresses. Among the men admitted for non-streptococcal diseases positive cultures were obtained in the following order: throats 80%, sheets 80%, mattress covers 60%, blankets 60%, mattresses 40%. Cultures of a group of 35 men with streptococcal diseases and their bedding showed that contamination was complete in 11.4% and partial

in 48 6% The degree of contamination among 40 men and their bedding, with streptococcal and non-streptococcal diseases, is shown in Table 6 The typing results of cultures from 68 ward patients and bedding are shown in Table 7. No cultures were made of 22 blankets, 4 sheets, 4 mattress covers and 1 mattress

Tables 6 and 7 show that even in the warm months when the incidence of streptococcal infections was low following cessation of recruit training at Farragut, there was nevertheless a high degree of contamination of bedding in the dispensary wards, including the blankets which were seldom used. The contaminating organisms fell into approximately the same classification as the strains cultured from the throat flora

SUMMARY

Studies were made to collect factual information on the presence and degree of streptococcal contamination at a Naval Activity The observations reported were made at a time when only sporadic streptococcal infections occurred. Some of the findings appeared conclusive:

Hemolytic streptococcus survived in floor dust for at least eight months in buildings which had been cleaned and locked

The highest degree of contamination of floor dust occurred in the dispensaries and scarlet fever ward of the Naval Hospital In addition, it was found that floor dust in the corridors of the central administration buildings and in the corpsmen's school was also heavily contaminated

A high degree of contamination of bedding was observed throughout the station This included bedding which had been aired and stored away for future use The highest degree of contamination of bedding occurred in wards where patients with streptococcal infections were treated.

The contamination of bedding of incoming and outgoing drafts was independent of a positive throat culture and independent of a positive nose culture

The facts collected at Farragut showed that even when the incidence of streptococcal infections was minimal, when the turnover of personnel was slow and when overcrowding did not exist, there was nevertheless a large reservoir of hemolytic streptococci in the floor dust and bedding

CHAPTER XV

OBSERVATIONS ON THE RELATION OF GEOGRAPHICAL ENVIRONMENT TO THE VIABILITY OF STREPTOCOCCUS HEMOLYTICUS IN DUST

It has been shown by a number of workers that floor dust, blankets and clothing may serve as reservoirs of hemolytic streptococcus (5, 25). Confirmation of these observations was made at U. S. Navy Activities during the winter and spring months of 1945. However, the degree of streptococcal contamination differed in several geographical locations.

At Farragut, a preliminary survey in Camp Bennion during January, 1945 showed that nine of eleven samples of floor dust were positive for Group A hemolytic streptococci in the dispensary wards and ship's service. Forty-four percent of 43 cultures of dust from various other buildings at Camp Bennion were positive. In this limited study the number of Group A streptococcal cultures and the concentrations of bacteria appeared to increase with the length of time that recruits occupied the barracks examined.

During the month of March a survey was made of the prevalence of hemolytic streptococci in samples of dust obtained from "secured" buildings. Sixty samples of dust obtained from the decks of the barracks and service buildings at Camp Scott were cultured for hemolytic streptococci. Twenty-two of these had presumably been thoroughly cleaned with 1–1000 grade A calcium hypochlorite solution. Thirty-six were not cleaned with hypochlorite Thirty percent of cultures from cleaned barracks were positive for Group A hemolytic streptococci and 25.4% of cultures from barracks not cleaned with calcium hypochlorite were positive.

Ten samples of dust from floors and ten from rugs in the administrative buildings were processed in April 1945. Seven of the ten floor samples were positive for hemolytic streptococci. The cultures from the rug dust were all negative

Cultures were made from one hundred blankets in the Outgoing Unit. Fifty-five contained Group A hemolytic streptococcus.

At Sampson, dust cultures from barracks, dispensaries, Ship's Service and classrooms were positive in 20 of 38 tests Six of these samples were collected in the dispensary and four were positive for Group A hemolytic streptococci.

One hundred blankets were cultured. Fifty of these belonged to men arriving from Great Lakes. Group A hemolytic srteptococci were obtained

in 40% The other 50 blankets belonged to men in the Outgoing Unit; 38% yielded cultures of Group A hemolytic streptococcus.

At Treasure Island, it was found that the floor dust was more heavily contaminated in the wards than in the barracks The scarlet fever wards were particularly heavily seeded The number of hemolytic streptococci from all samples collected was:

	Colonies per 1 Milligram of Dust				Total Cultures
	0	1-10	10-100	Over 100	
Barrack cultures	90	88	80	18	276
Hospital Ward cultures	4	3	2	6	15

These observations confirmed the findings of other investigators. However, they did not supply any information on the length of time that the floor dust or blanket lint may have been contaminated To collect information on this point, preliminary observations were made at Farragut, Idaho

A. THE DURATION OF VIABLE HEMOLYTIC STREPTOCOCCI IN DUST AT FARRAGUT, IDAHO

Attention has been called to the fact that hemolytic streptococcus maintained its infectivity and pathogenicity throughout all months of the year at Farragut, Idaho In fact, as pointed out, there was a sharp rise in streptococcal morbidity during each summer that this Naval Center trained recruits These epidemic conditions developed at a time when streptococcal activity was absent or minimal at all other Naval installations The mechanism of this reactivation of hemolytic streptococcus in August of 1944 and 1945 was unknown Other than Man, no animals were found which harbored Group A hemolytic streptococcus However, dust was shown to serve as a potential reservoir of this respiratory tract pathogen It appeared that hemolytic streptococcus might survive in this reservoir and be widely disseminated when dust storms occurred at Farragut in the warm, dry months of summer To collect information on this possibility the following preliminary study was made:

Camp Ward at Farragut was closed and sealed between November 25 and December 6, 1944 At this time the floors of the dispensary were swabbed with soap and warm water, waxed and buffed Then the floors, baseboards, overheads, pipes, uprights and unfinished walls of the barracks were dry wiped and sprayed with a 1-1000 solution of grade A calcium hypochlorite Beginning in February, 1945, ten samples of floor dust were cultured each month from these dispensaries by the station's epidemiolo-

gist. Appropriate precautions were taken to avoid the introduction of organisms from without. As late as six months after the dispensaries were secured, *eight of ten dust cultures were positive for hemolytic streptococcus* One month later two of ten remained positive for types 19, 17 and 1. During August, 1945, eight months after these dispensaries were cleaned and sealed, the floor dust became free of hemolytic streptococcus for the first time. This observation was not confined to Camp Ward. Fifty-one dust samples from closed dispensaries of open camps at Farragut were also processed. Twenty-five of these samples contained Group A hemolytic streptococcus. These findings made in 1945 at Farragut demonstrated that several types of Group A hemolytic streptococcus survived in floor dust approximately eight months of winter, spring and summer under conditions where nothing was done to shorten or prolong their survival time.

B. THE SURVIVAL OF HEMOLYTIC STREPTOCOCCUS IN DUST DURING SUMMER MONTHS—A COMPARISON BETWEEN FARRAGUT, IDAHO AND OTHER POINTS OF THE UNITED STATES

The same types of hemolytic streptococcus and probably some of the same strains which survived in the dust of Farragut were prevalent at other Naval stations in the spring months of 1945. However, with the onset of summer, streptococcal infections disappeared at all Naval Centers except Farragut It was suggested that the striking difference in streptococcal morbidity rates at Farragut and other Centers might be attributed to the fact that hemolytic streptococcus survived in floor dust at Farragut during the warm months To determine whether this occurred at other Centers identical studies were initiated in parallel at Naval Activities in five other areas of the United States: New York, Illinois, Tennessee, Oklahoma and Maryland These studies on dust contamination were made by the Epidemiology Units which had investigated the streptococcal problems of their stations for at least two years. Observations were recorded in uniform manner between June and October, 1945. Each of these Epidemiology Units received the following directions:

"*Plan of Study* Beginning Monday, 4 June 1945, obtain fifty (50) cultures of floor dust weekly from areas used by recruits as follows ten cultures from hospital scarlet fever wards, ten cultures from dispensary wards, five cultures from Ship's [illegible]

1–1000 and 1–10,000 dilutions After 24 hours' incubation examine the pour plates for hemolytic streptococcus colonies Make counts of these colonies and record as number per gram of dust Isolate hemolytic streptococcus in pure culture, group and send Group A organisms to the National Naval Medical Center Laboratory for typing and sulfonamide resistance studies

"*Method of Culturing Blankets*· The blood agar plate is to be used for collecting micro-organisms from blankets First, the deck must be swabbed to eliminate dust. The blanket to be tested is held by two men, tentlike, folded in the center with both sides closely approximated. The blanket is not to be beaten or shaken but shall be moved *vertically* about six inches above the open blood agar plate for two minutes Plates are to be examined after 10 and 18 hours' incubation at 37°C A rough quantitative determination of streptococcal growth shall be recorded as 1+ to 4+. Hemolytic streptococcal colonies shall be identified, grouped and sent for typing and resistance studies"

1. *Observations at Farragut, Idaho* This station had received no recruits for over six months, most of its buildings were closed; its population which had been over 50,000 in 1944 was reduced to 5,000 men; the incidence of streptococcal infections had fallen to its lowest level since the station was commissioned

The four months' survey to determine the survival of hemolytic streptococci in the dust of blankets and the dust from floors of barracks and hospital wards was completed by October 1, 1945 A total of 816 samples was taken from floors and a total of 840 samples was taken from blankets using the method of sampling described in Chapter XX Samples of beta hemolytic streptococci recovered were subcultured and sent to the Naval Streptococcal Typing Laboratory in Bethesda. Three groups were identified, i e, "A," "C," and "G" The remainder of the samples was designated either "Not A or C" or "Not A, C or G" All group A streptococci were typed Tables 1 and 2 show that Group A streptococci were recovered every week of the summer months from the dust at Farragut.

In summary, Group A hemolytic streptococcus was recovered from floor and blanket dust, or either, every week of the summer months This observation was made when the station had been closed to recruit training for six months, when the population was small and when the incidence of streptococcal infections had reached the lowest endemic level. More than twelve serologic types were identified Of those identified serologically, types 17 and 19 were predominant As was shown in Chapter XIII, some of the type 17 organisms appeared to be peculiarly resistant to direct summer sunlight and high temperatures

2. *Observation at Sampson, New York* Streptococcal infections persisted at the Sampson Naval Training Center during the summer of 1945 There were 344 cases of scarlet fever in June, 187 in July, a smaller number in August and an increase in all streptococcal infections in September. For the first time in the history of this Center, scarlet fever persisted through-

gist. Appropriate precautions were taken to avoid the introduction of organisms from without. As late as six months after the dispensaries were secured, eight of ten dust cultures were positive for hemolytic streptococcus. One month later two of ten remained positive for types 19, 17 and 1. During August, 1945, eight months after these dispensaries were cleaned and sealed, the floor dust became free of hemolytic streptococcus for the first time. This observation was not confined to Camp Ward. Fifty-one dust samples from closed dispensaries of open camps at Farragut were also processed. Twenty-five of these samples contained Group A hemolytic streptococcus. These findings made in 1945 at Farragut demonstrated that several types of Group A hemolytic streptococcus survived in floor dust approximately eight months of winter, spring and summer under conditions where nothing was done to shorten or prolong their survival time.

D. THE SURVIVAL OF HEMOLYTIC STREPTOCOCCUS IN DUST DURING SUMMER MONTHS—A COMPARISON BETWEEN FARRAGUT, IDAHO AND OTHER POINTS OF THE UNITED STATES

The same types of hemolytic streptococcus and probably some of the same strains which survived in the dust of Farragut were prevalent at other Naval stations in the spring months of 1945. However, with the onset of summer, streptococcal infections disappeared at all Naval Centers except Farragut. It was suggested that the striking difference in streptococcal morbidity rates at Farragut and other Centers might be attributed to the fact that hemolytic streptococcus survived in floor dust at Farragut during the warm months. To determine whether this occurred at other Centers identical studies were initiated in parallel at Naval Activities in five other areas of the United States. New York, Illinois, Tennessee, Oklahoma and Maryland. These studies on dust contamination were made by the Epidemiology Units which had investigated the streptococcal problems of their stations for at least two years. Observations were recorded in uniform manner between June and October, 1945. Each of these Epidemiology Units received the following directions:

"*Plan of Study* Beginning Monday, 4 June 1945, obtain fifty (50) cultures of floor dust weekly from areas used by recruits as follows· ten cultures from hospital scarlet fever wards, ten cultures from dispensary wards, five cultures from Ship's Service, five cultures from classrooms, and twenty cultures from barracks

"Beginning Monday, 4 June 1945, test ten blankets from hospital wards, ten from dispensary respiratory disease wards, and thirty from the Out Going Unit.

"*Method of Culturing Floor Dust* Obtain samples of dust by sweeping the deck and collecting dust samples in sterile Petri dishes The broom during sweeping operations is to be covered by a clean flannel cloth Each strip is used once and then discarded Suspend one gram of dust in Ringer solution and agitate. Make suitable dilutions so that 1 cc of this suspension when added to blood agar pour plates will give

TABLE 2

Number of Samples of Viable, Group A, Beta Hemolytic Streptococci (by Types) Recovered from Floor Dust or Blanket Dust of Barracks, Hospital Wards, etc, from June 10, 1945 to October 1, 1945

Weeks	SAMPLES FLOOR DUST														SAMPLES BLANKET DUST													
	No	Number Positive* (types)													No	Number Positive* (types)												
		17	19	NCT	3	5	24	6	14	30	44	12	18	1		17	19	NCT	3	5	24	6	14	30	44	12	18	1
1	16														40	1	2		1									
2	50	1	2	2						1					50	4	2	1										1
3	50	4	1	2					1						50													
4	50	1	1	1	1	1		1							50	2	3	1			1							
5	50	1	6	1											50	1		2			1							
6	50	2													50	2	2	1										
7	50	4		1											50	2	3	1										
8	50	1		3											50	1	2	1										
9	50														50													
10	50			2				1			1	1			50							1				1		
11	50			3							1		1		50			1							1			
12	50	1			1										50	1												
13	50			1										1	50													
14	50														50			1										
15	50														50			3										
16	50														50	2	1											
17	50	1													50			1										
Total	816	16	10	16	2	1		2	1	1	2	1	1	1	840	16	15	13	1		2	1			1	1		1

* Positive · Samples exhibiting beta hemolytic streptococcal growth and identified as types of Group A

out the summer months at Sampson. The predominant organisms were Re strains of type 19. Other types prevalent were 17, 1, 30, 6 and 3.

Floor Dust: The amount of contamination roughly paralleled the streptococcal morbidity rates of the summer months. The types of organisms recovered were those which caused most of the streptococcal diseases on the station. The heaviest contamination was in the scarlet fever wards in

TABLE 1

Number of Samples of Viable Beta-hemolytic Streptococci Recovered from Deck Dust or Blanket Dust of Barracks, Hospital Wards, etc., from 10 June, 1945, to 1 October, 1945

Weeks	Samples Deck Dust							Samples Blanket Dust						
	Number Positive* (Groups)													
	No.	A	C	G	Not AC	Not ACG	Total	No	A	C	G	Not AC	Not ACG	Total
1	16					4	4	40	4	4				8
2	50	7	2			5	14	50	8	1			1	10
3	50	8	3			1	12	50						
4	50	6	2			2	10	50	7	1	1		1	10
5	50	8	1	3			12	50	4		1			5
6	50	2					2	50	4					4
7	50	5		3		1	9	50	6	1			1	8
8	50	4	1			1	6	50	4					4
9	50		1			3	4	50						
10	50	6				1	7	50	2	4			1	7
11	50	5			3		8	50	2	2				4
12	50	2	4		1		7	50	1	3		4		8
13	50	2		1			3	50		1				1
14	50							50	1	1	4		1	7
15	50							50	3	1				4
16	50				1		1	50	3			1		4
17	50	1	1				2	50	1	6				7
Total	816	56	15	7	5	18	101	840	50	25	6	5	5	91

* Positive Samples exhibiting beta hemolytic streptococcal growth and identified by groups

June. Over the four-month period 21.9% of 801 dust samples contained hemolytic streptococcus. These findings are shown in Table 3.

Blanket Dust: The amount of contamination of 819 blankets also roughly paralleled the morbidity rates for streptococcal diseases. The heaviest contamination occurred in the dispensary and scarlet fever wards during June. By August, streptococcal contamination had almost disappeared; however, the percentage of positive cultures increased in September. These findings are shown in Table 4.

from classrooms, twenty from barracks, ten from dispensaries and five from Ship's Service Canteens.

Fifty blanket samples were collected each week for 18 weeks as follows: ten from U. S. Naval Hospital wards, 40 from Great Lakes Training Center, including 30 from the blankets of men in the Outgoing Unit and 10 from dispensary beds.

One gram of dust was collected aseptically in a sterile water-proofed paper bag. The dust was suspended in Ringer's solution to dilutions of 1–1000 and 1–10,000 Isolated colonies were picked and grouped in the laboratory of Epidemiology Unit #13. Group A streptococci were sent for typing to the Streptococcal Typing Laboratory, U S. Naval Medical

TABLE 5

Studies on the Viability of Hemolytic Streptococci in Dust U S N.T C, Great Lakes, Illinois

1945 Date	Hospital			Ship's Service			Barracks			Classrooms			Dispensaries		
	Pos *	Neg	% Pos	Pos	Neg	% Pos.	Pos	Neg	% Pos	Pos	Neg	% Pos	Pos	Neg	% Pos
6/4–6/16	7	13	35	0	10	0	9	31	23	3	7	30	13	7	65
6/18–6/30	5	15	25	1	9	10	6	34	15	2	8	20	4	16	20
7/2–7/14	2	18	10	0	10	0	2	36	5	2	8	20	5	17	25
7/16–7/28	1	19	5	1	9	10	5	35	13	3	7	30	6	14	30
7/30–8/11	2	18	10	0	10	0	6	34	15	1	9	10	4	16	20
8/13–8/25	4	16	20	1	9	10	3	37	8	1	9	10	2	18	10
8/27–9/8	3	17	15	0	10	0	1	39	3	0	10	0	4	16	20
9/10–9/22	5	15	25	0	10	0	3	37	8	1	9	10	3	17	15
9/24–10/6	1	19	5	0	10	0	4	36	10	1	9	10	7	13	35

* "Positive"—Group A hemolytic streptococci

Total of all samples Pos —132
Neg —768
%Pos —15

School, Bethesda, Maryland The findings in each of the five sources (Hospital Wards, barracks, etc) arranged in two week intervals are shown in Table 5

Two methods were used for collecting 900 samples of dust from blankets:

(1) A blood agar plate was placed on a freshly swabbed floor and the horizontally folded blanket was moved vertically over the plate for two minutes

(2) The blanket was spread out on a bunk or table and a blood agar plate was patted gently over both surfaces.

The second method appeared at this Center to be the more satisfactory of the two The findings are presented in Table 6.

In summary, scarlet fever had disappeared abruptly at Sampson during June of 1943 and 1944. However, in 1945, scarlet fever was present during the summer months. An appropriate sample of cultures was grouped and typed. Infections were caused by Rc type 19 strains and other types of Group A hemolytic streptococcus. Since these infections persisted throughout the summer of 1945 it was not possible to make an accurate appraisal of the survival time of Group A streptococci in dust. The incidence of positive cultures in floor dust and blanket dust appeared to

TABLE 3

Distribution of Hemolytic Streptococcal Cultures in Dust of Buildings at Sampson

Month	Scarlet Fever Wards			Dispensary Wards			Barracks			Classrooms			Ship's Service		
	Total No	%+	%−	Total No	%+	%−	Total No	%+	%−	Total No	%+	%−	Total No	%+	%−
June	41	78	22	32	38	62	81	27	73	15	27	73	14	7	93
July	31	39	61	35	29	71	81	17	83	13	8	92	18	33	67
August	30	7	93	44	18	82	105	13	87	18	10	90	21	19	81
September	40	2	98	42	11	89	100	20	80	20	10	90	20	15	85
Total	142			153			307			66			73		

TABLE 4

The Distribution of Cultures of Hemolytic Streptococcus from Blankets at Sampson

Month	Scarlet Fever Wards			Dispensary Wards			Barracks		
	Total No	%+	%−	Total No	%+	%−	Total No	%+	%−
June	33	24	76	30	53	47	108	20	80
July	29	14	86	32	16	84	150	3	97
August	38	8	92	22	0	100	139	0	100
September	30	16	84	48	4	96	160	6	96
Total	130			132			557		

reflect the prevalence of streptococcal diseases The sharp drop in the incidence of positive dust cultures during August is interpreted as an indication that the survival time of Group A streptococci in Sampson dust was not more than two months

3. *Observations at Great Lakes, Illinois.* Viability studies of hemolytic streptococci were started June 4, 1945 and terminated October 6, 1945. Fifty samples of dust were collected each week for 18 weeks as follows: ten from hospital wards and forty from the Training Center, including five

Weekly cultures of floor dust and blankets were made from June 4 to August 1 and again on September 1 and November 30 Several techniques in addition to the one directed were used and all hemolytic colonies were processed Hemolytic streptococci of Group C were frequently isolated. However, not one colony of Group A hemolytic streptococcus was recovered from blanket or floor dust in dispensaries, classrooms, barracks, Ship's Service or scarlet fever wards of the Naval Hospital.

In summary, during the winter months this station had a streptococcal outbreak caused by type 17 Re 125. After June 1, 1945, all attempts to recover Group A hemolytic streptococcus from floor dust and blankets were unsuccessful The disappearance of this bacterium from these reservoirs preceded the disappearance of scarlet fever. Under conditions existing at Memphis in the late spring and summer of 1945, the survival time of hemolytic streptococcus in floor dust and blankets must have been extremely brief.

5 *Observations at Norman, Oklahoma.* The Naval Air Technical Training Center at Norman had a high incidence of streptococcal infections during the spring months of 1945 Streptococcal infections were caused chiefly by types 19, 17, 3 and 6. Scarlet fever persisted until the middle of June Only sporadic cases of acute tonsillitis and pharyngitis occurred throughout the summer months

The floors [illegible]

from these floors before the first morning sweeping

The Ship's Service stores had rough concrete floors, the libraries, auditoriums, chapel, and game rooms had wooden floors. All concrete floors were mopped with a cleaning compound each night and swept about twice during the day Samples of dust were taken from these floors at about 10 A M The wooden floors were swept daily and some of them were waxed occasionally Depending on location, some of the classroom floors were concrete and some wooden These were cleaned by sweeping and mopping All samples were taken from classrooms in use.

The barracks had wooden floors except in the toilets and lavatories which were of concrete. All floors in the barracks were rubbed down with steel wool once a week before inspection and were swept daily Antiseptic and deodorizing compounds were used in the toilets A great quantity of dust was found in the barracks and this may be attributed to the fact that floors were steel-wooled and swept dry without cleaning compound None of the floors in this Center had ever been oiled

Floor Dust Cultures Fifty samples of dust were collected each week from June 1 to October 1, 1945 These samples were obtained from five sources:

The results of culturing floor dust show that there was least streptococcal contamination in the Ship's Service and most in the dispensaries where streptococcal infections were treated. Cultures positive for Group A hemolytic streptococcus were obtained as follows: Dispenaries 26%, hospital wards 17%, classrooms 16%, barracks 11%, Ship's Service canteens 3%. In August, contamination was rarely detected in the dust from barracks, classrooms or Ship's Service.

The results of culturing blankets were similar. The dispensaries where streptococcal infections were treated had the largest percentage of contaminated blankets. During August, hemolytic streptococci were not recovered in the blankets of recruits in the Outgoing Unit and only rarely in the wards.

TABLE 6

Studies on the Viability of Hemolytic Streptococci in Blankets· U.S N.T C., Great Lakes, Illinois

1945 Date	U.S.N Hospital			Dispensaries			OGU			Total		
	Pos.	Neg	% Pos	Pos	Neg	% Pos	Pos	Neg	% Pos.	Pos	Neg	% Pos.
6/4–6/16	0	20	0	10	10	50	2	58	3	12	88	12
6/18–6/30	0	20	0	2	18	10	2	58	3	4	96	4
7/2–7/14	0	20	0	0	20	0	0	60	0	0	100	0
7/16–7/28	2	18	10	4	16	20	12	48	20	16	84	16
7/30–8/11	0	20	0	0	20	0	0	60	0	0	100	0
8/13–8/25	0	20	0	0	20	0	0	60	0	0	100	0
8/27–9/8	1	19	5	2	18	10	0	60	0	3	97	3
9/10–9/22	0	20	0	2	18	10	0	60	0	2	98	2
9/24–10/6	0	20	0	0	20	0	2	58	3	2	98	2
Total	3	177	2	20	160	11	18	522	3	41	850	5

In summary, during the winter and spring months of 1945, this Training Center had experienced a severe epidemic of scarlet fever from Re strains of types 19, 17 and 3 The morbidity rates declined rapidly but remained moderately elevated in the early summer months. Hemolytic streptococci failed to survive after July either in floor dust or in blankets The positive cultures earlier in June are interpreted as a reflection of the elevated streptococcal morbidity rates present during the early summer months.

4 *Observations at Memphis, Tennessee* A moderately severe epidemic of scarlet fever occurred on this Naval Air Technical Training Center during the winter and early spring months of 1945 This subsided in April. The morbidity rates for scarlet fever were 20 for May, 7 3 for June, 4 5 for July, 0 for August, September, October and November.

Weekly cultures of floor dust and blankets were made from June 4 to August 1 and again on September 1 and November 30 Several techniques in addition to the one directed were used and all hemolytic colonies were processed Hemolytic streptococci of Group C were frequently isolated. However, not one colony of Group A hemolytic streptococcus was recovered from blanket or floor dust in dispensaries, classrooms, barracks, Ship's Service or scarlet fever wards of the Naval Hospital.

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The floors in all the dispensaries and scarlet fever wards were wet mopped at least once a day, waxed at least once a week, and dry swept several times a day No sweeping compound was used Samples of dust were taken from these floors before the first morning sweeping

The Ship's Service stores had rough concrete floors, the libraries, auditoriums, chapel, and game rooms had wooden floors All concrete floors were mopped with a cleaning compound each night and swept about twice during the day Samples of dust were taken from these floors at about 10 A M The wooden floors were swept daily and some of them were waxed occasionally Depending on location, some of the classroom floors were concrete and some wooden These were cleaned by sweeping and mopping All samples were taken from classrooms in use

The barracks had wooden floors except in the toilets and lavatories which were of concrete All floors in the barracks were rubbed down with steel wool once a week before inspection and were swept daily Antiseptic and deodorizing compounds were used in the toilets A great quantity of dust was found in the barracks and this may be attributed to the fact that floors were steel-wooled and swept dry without cleaning compound None of the floors in this Center had ever been oiled

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1945 Date	U.S.N Hospital			Dispensaries			OGU			Total		
	Pos.	Neg	% Pos.	Pos	Neg	% Pos	Pos	Neg	% Pos.	Pos.	Neg	% Pos
6/4–6/16	0	20	0	10	10	50	2	58	3	12	88	12
6/18–6/30	0	20	0	2	18	10	2	58	3	4	96	4
7/2–7/14	0	20	0	0	20	0	0	60	0	0	100	0
7/16–7/28	2	18	10	4	16	20	12	48	20	16	84	16
7/30–8/11	0	20	0	0	20	0	0	60	0	0	100	0
8/13–8/25	0	20	0	0	20	0	0	60	0	0	100	0
8/27–9/8	1	19	5	2	18	10	0	60	0	3	97	3
9/10–9/22	0	20	0	2	18	10	0	60	0	2	98	2
9/24–10/6	0	20	0	0	20	0	2	58	3	2	98	2
Total	3	177	2	20	160	11	18	522	3	41	859	5

[illegible] months of 1945 this Training [illegible]

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TABLE 7

Concentration and Distribution of Group A Hemolytic Streptococcus at Norman

	Date	Culture Number	Colony Count per Gram Dust	Group-type
Scarlet Fever Wards	6-8-45	D-42	4,000	A-17
	6-9-45	D-45	1,000,000	A-17
	6-8-45	D-40	10,000	A-17
	6-8-45	D-41	180,000	A-17
	6-13-45	D-84	10,000	A-19
	6-18-45	D-107	60,000	A-19
	6-18-45	D-108	120,000	A-17
	6-19-45	D-124	20,000	A-19
	6-20-45	D-136	70,000	A-19
	6-21-45	D-144	450,000	A-19
	6-21-45	D-145	200,000	A-19
	6-22-45	D-148	50,000	A-19
	6-28-45	D-188	8,000	A-19
	7-2-45	D-208	190,000	A-19
	7-9-45	D-225	350,000	A-17
	7-12-45	D-288	30,000	A-17
	8-2-45	D-437	200,000	A-19
	8-2-45	D-438	40,000	A-19
	8-7-45	D-465	2,500,000	A-19
	8-7-45	D-466	3,000,000	A-19
	8-8-45	D-475	60,000	A-19
Dispensaries	6-9-45	D-54	30,000	A-17
	6-18-45	D-115	25,000	A-12
	6-19-45	D-117	14,000	A-19
	6-28-45	D-195	5,000	A-17
Classrooms	6-7-45	D-1	10,000	NCT
	6-11-45	D-66	5,000	A-19
	6-20-45	D-127	40,000	A-17
	7-3-45	D-225	1,000	A-17
	7-9-45	D-259	1,000	A-6
	7-20-45	D-341	3,000	A-1
	6-7-45	D-8	200,000	A-6
	6-18-45	D-112	30,000	A-12
	6-19-45	D-120	20,000	A-17
	6-28-45	D-190	1,000	NCT
	8-7-45	D-472	1,000	NCT
	8-9-45	D-492	60,000	A-12
Ship's Service	6-8-45	D-110	10,000	A-12
	6-22-45	D-149	20,000	NCT
	8-2-45	D-439	20,000	NCT

thirty barracks, ten dispensaries, ten scarlet fever wards, five classrooms, five Ship's Services. A total of 900 samples was processed. The bacteriologic findings were:

(a) Forty cultures of Group A streptococcus were obtained from dust in the summer months Twenty-six of these were obtained in June when scarlet fever was still present. Then a sharp fall in the number of positive Group A cultures occurred with six in July, eight in August, and none in September. Sixty additional cultures were made in October; only one of these was positive.

(b) The heaviest contamination was found in the scarlet fever ward where 11.7% of cultures contained Group A hemolytic streptococcus of types 19 and 17

(c) Group A organisms were also grown from the dust of other buildings: barracks, six of 360, classrooms, five of 90, dispensaries, four of 180; Ship's Service, three of 90 The types identified were 19, 17, 12, 6 and 1.

(d) The degree and distribution of contamination with strains of hemolytic streptococcus identified as Group A are shown in Table 7.

Blanket Cultures Fifty blanket cultures were made each week; thirty from men in the Outgoing Unit, ten from the scarlet fever ward and ten from the dispensaries The blankets from the scarlet fever ward and the dispensaries had been used by many persons between launderings. Altogether 800 samples from blankets were cultured. Group A hemolytic streptococcus was recovered from seven of these blankets; six in June and one in July The types identified were 12, 19, 17 and 3.

In summary, the types of hemolytic streptococcus active on this station were grown from dust cultures during the early part of the summer when scarlet fever persisted These organisms disappeared from floor and blanket dust during the middle of the summer. The presence of hemolytic streptococcus in dust from the floors and blankets seemed to be associated with acute infections It appeared that survival of Group A streptococcus at Norman, Oklahoma, was of short duration in the dust of floors and blankets during the summer months of 1945.

6 *Observations at Bainbridge, Maryland* The incidence of streptococcal infections reached a peak at Bainbridge Naval Training Center during the winter months of 1945 and high morbidity rates persisted during the spring months. The predominant organisms were Ro strains of types 17 and 19. Other prevalent types were 6, 24, 3 and 1 Between 30% and 60% of men returning from the Naval Hospital carried Group A hemolytic streptococcus in their throat flora During the latter half of May and June, all convalescents who were carriers of hemolytic streptococcus and had elevated blood sedimentation rates were isolated for two weeks. The insti-

In summary, Group A hemolytic streptococcus was not recovered in the floor dust or dust from the blankets after June 26th at Bainbridge Naval Training Center The organisms identified in June were of the types prevalent during the spring months Most of the blankets from which cultures were made during June and July had been exposed to men with streptococcal infections Most of the locations with contaminated floor dust were exposed to heavy seeding with Group A streptococci during the months of April and May. The findings show that the survival time of Group A hemolytic streptococcus in dust from floors and blankets was short during the summer of 1945 at Bainbridge, Maryland

SUMMARY

Streptococcal infections either disappeared or reached low morbidity levels at all Naval Activities in the summers of 1942, 1943, and 1944, except at Farragut, Idaho

The conditions at Farragut in the summer of 1945 were unfavorable to the spread of streptococcal infections. No recruits were trained, the station complement was small and relatively fixed, crowding did not exist. Streptococcal morbidity rates reached their lowest level with only sporadic cases of tonsillitis. In spite of these conditions, contamination of floor dust and bedding persisted throughout the summer months Furthermore, it was shown that the survival time of hemolytic streptococcus in dust at this location was at least eight months and that one strain, type 17 Re 125, had an unusual capacity to withstand solar radiation and heat.

In the summer of 1945, the incidence of streptococcal infections reached low endemic levels at all stations except Sampson where moderately elevated rates persisted Cultures from the dust of floors and blankets at Sampson showed that contamination was closely associated with the incidence of infections. However, the survival time of Group A hemolytic streptococcus appeared to be not more than two months in the summer of 1945

At Great Lakes, Bainbridge, Memphis and Norman the survival time appeared to be much shorter No Group A organisms were recovered from floor dust or blanket lint at Memphis during the summer of 1945

These observations showed that contamination of floor dust and blanket lint persisted for over six months at the northernmost Naval Activity (Farragut) and perhaps for two months at another Northern Activity (Sampson) and disappeared rapidly at the most Southern Naval Activity (Memphis).

There appeared to be a close relation between the geographical location of a Training Center and the viability of hemolytic streptococcus in reservoirs of dust and blanket lint

tution of this precaution was followed by a precipitous fall in the incidence of streptococcal diseases and "the admission rates were consistently the lowest of all training centers" during the summer months.

Floor Dust Cultures: A total of 811 samples of floor dust was collected between June 1 and October 1, 1945 These samples were taken from many locations in most of the buildings in each of the camps and in the Naval Hospital. In the training camps the buildings were well ventilated; the floors were cleaned with "steel wool," treated with a mixture of creosote and wax once a week and swept daily. Likewise, in the hospital the wards were well ventilated; the floors were treated at least once a week with a solution of creosote, soap and water, and were swept at least twice a day.

The bacteriologic findings were:

Camp I: 30 samples of dust were examined. The only Group A hemolytic streptococcus recovered was on June 8. It was type 17 Re 25.

Camp II: 178 samples of dust were examined. No Group A organisms were recovered

Camp III: 216 samples of dust were examined. The only Group A organisms recovered were from samples of June 7. Two were type 24; the others were 17 Re 25, 19 Re 25 and type 19.

Camp IV: 210 samples of dust were examined. The only Group A organisms recovered were from samples of June 26. They were 17 Re 125 and 19 Re 25

Naval Hospital: 177 samples of dust were examined. There were five positive cultures in June which were not identified by Group or type. No Group A organisms were recovered after June 26.

Dust from Blankets A total of 836 samples of blanket dust was collected between June 1 and October 1, 1945 Most of them had been in use for several months without laundering The results of these studies were:

Outgoing Unit. 492 cultures were made from blankets of men leaving Bainbridge These men had been at Bainbridge for two months or longer. The blankets were issued to them on first reporting to duty and had not been washed The only two Group A organisms, type 19 Re 25 and Re 5, were isolated in June

Naval Hospital. 184 cultures were made from blankets which had been unlaundered from one week to thirteen weeks No Group A organisms were recovered

Dispensaries 160 cultures were made from the blankets of the four camp dispensaries All of these blankets had been in use without laundering from one to nineteen weeks most of them had been in use for two months Four Group A organisms were recovered on June 4th from blankets in the dispensary of Camp IV. These organisms were all Re strains of type 17

In brief, the findings were:

1. *Indianapolis*· Over 300 men were barracked together on the concrete flooring of this Naval Armory. There were many large cracks in the flooring and a great deal of dust collected in these crevices. All samples of this dust processed during the spring months of 1945 were heavily contaminated with types 17 and 19 organisms indistinguishable from those causing an epidemic at this Naval Activity.

2. *Great Lakes* One hundred and eight floor dust samples were collected from buildings of six recruit camps, the Receiving Unit (Camp Barry) and the McIntyre Dispensaries, during the spring months of 1945 after an epidemic of scarlet fever had subsided Positive cultures were obtained in 57% of samples and 18% of samples were shown to be Group A The heaviest contamination with Group A organisms was in the wards of camp dispensaries and the scarlet fever and pharyngitis wards of the McIntyre Dispensary. The passageway of the Receiving Unit was heavily contaminated with type 3 Re 1. No Group A organisms were obtained from the dust in the Negro camp, Robert Smalls, where the incidence of streptococcal infections had remained low and scarlet fever had not been observed during the epidemic.

3. *Sampson*· Thirty-eight floor dust samples were collected from different locations in the camps of this station during the subsidence of an epidemic in the spring months of 1945 Half of these samples were positive for Group A hemolytic streptococcus The highest degree of contamination was in the scarlet fever Convalescent Barracks

4. *Farragut*· Floor dust studies were made over a period of several winter months in 1945 to determine factors which might influence the degree of contamination in the buildings on this station after epidemic conditions had subsided The findings were reported previously in detail. Several thousand cultures were made and contamination was found in almost every location. In the dispensaries which had been used by recruits, 25 of 51 samples contained Group A hemolytic streptococcus, in dispensaries used by other personnel, only 2 of 18 samples were positive

Three exceptions of interest were noted during this study First, none of 40 dust samples obtained from the steam radiators in contaminated locations contained hemolytic streptococci Second, only 4 of 117 cultures from Camp Bennion were positive. This observation in Camp Bennion was repeated and all cultures of floor dust were found to be negative. This camp had been closed for two months The only difference detected was that all floors in Camp Bennion had been cleaned with a 1 to 10 dilution of calcium hypochlorite instead of a 1 to 1,000 dilution which was used elsewhere throughout the station Between 45% and 80% of samples of dust from

CHAPTER XVI

OBSERVATIONS ON THE ASSOCIATION BETWEEN INANIMATE AND ANIMATE RESERVOIRS OF STREPTOCOCCUS HEMOLYTICUS AT NAVAL TRAINING ACTIVITIES

Evidence was presented early in World War II that certain persons who had recovered from acute streptococcal infections remained *dangerous carriers* and spread streptococcal diseases in hospital wards (26). These early *observations were made of men who were readmitted to a Naval Hospital.* Their bedding and clothing were not brought to the hospital ward with them. Later it was repeatedly shown that drafts of men, and in some instances single individuals, initiated streptococcal outbreaks. These outbreaks were caused by strains of hemolytic streptococcus which were carried in the nasopharynx from one station to another. Men in these drafts did *bring their blankets and other items issued by the Navy with them.* Cultures from these articles showed that they were heavily contaminated with hemolytic streptococcus. In addition, it was also shown that the floor dust of buildings which housed infected persons or carriers of hemolytic streptococcus was heavily contaminated with the strains present in the nasopharynx *However, information was lacking on the relative "epidemiogenic" importance of the human carrier of Group A hemolytic streptococcus and his contaminated belongings* This study deals with observations on several reservoirs of hemolytic streptococcus and their interrelation.

A THE RELATION OF THE PREVALENCE OF STREPTOCOCCAL INFECTIONS TO FLOOR DUST CONTAMINATION

Some of the bacteriologic findings on floor dust cultures made during the spring months of 1945 at the Indianapolis Armory and at the Training Centers of Great Lakes, Sampson and Farragut have been described

During these months epidemic conditions existed at all of these activities except Farragut which had been closed to recruit training. In these studies, one gram of dust was used for each analysis The number of hemolytic streptococci per gram of dust diluted to 1 to 10,000 was determined. One or two colonies of hemolytic streptococci from each culture were grouped and typed *Sulfonamide resistance tests were made of a* large sample of the strains

(c) Of the 85 men whose throat cultures were positive for hemolytic streptococcus, the bedding of 66 (78%) was also positive.

(d) Thirty-two men had negative throat cultures. Thirteen (41%) had bedding contaminated with hemolytic streptococci

This group of men with a high carrier rate for hemolytic streptococcus also had a high degree of contamination of bedding The degree of association between positive throat cultures and positive bedding cultures was determined by application of the Chi square and "X over Sigma" formulae with the following results.

TABLE 1

Results of Throat (T), Mattress Cover (MC), and Blanket (B) Cultures on 117 Prisoners from Bremerton

Results	Number	Percent
T−, MC−, B−	19	16 2
T−, MC+, B−	4	3 4
T−, MC+, B+	3	2 6
T−, MC−, B+	6	5 2
T+, MC+, B+	27	23 1
T+, MC+, B−	26	22 2
T+, MC−, B+	13	11 1
T+, MC−, B−	19	16 2
Total	117	100 0

Throat cultures positive	85	72 6%
Blanket cultures positive	49	41 9%
Mattress cover cultures positive	60	51 3%
Throat cultures and bedding cultures positive	85	72 6%

(a) The high rate of contamination of bedding among men with positive throat cultures could not have occurred by chance (probability equals 1 in 10,000; level of significance used throughout is 5 in 100), if the criterion for contamination was only hemolytic streptococcus

(b) The high degree of association between positive throat cultures and positive bedding cultures could only be attributed to the contamination of the mattress covers, not the blankets The number of contaminated blankets used by the 85 men with positive throat cultures was 40, this result could occur by chance 11 or more times in every 100 The number of contaminated mattress covers belonging to the same group of 86 men was 53. According to the Chi square formula, this could have occurred by chance only once in 6000 trials.

other camp barracks and dispensaries, which had been cleaned with a dilution of 1 to 1,000 and closed, were positive. Third, dust from the scarlet fever wards of the hospital, which had been heavily contaminated prior to the covering of the floor with battleship linoleum, was found to be free of hemolytic streptococcus after these wooden floors were covered.

In summary, the degree of streptococcal contamination of floor dust, which varied in the buildings and camps of each station, appeared to be associated with the *incidence* of streptococcal infections among the occupants of buildings at Naval Training Activities. The organisms prevalent in the throat flora were indistinguishable from the organisms prevalent in dust.

B THE RELATION OF POSITIVE NASOPHARYNGEAL CULTURES TO CONTAMINATION OF BEDDING

Studies at Great Lakes, Sampson and Farragut showed that blankets and other bedding were *heavily* contaminated with Group A hemolytic streptococcus In brief, throat cultures were made of 50 men in the Outgoing Unit of Great Lakes just prior to their departure. Seventeen were carriers of Group A hemolytic streptococcus. Three men had blankets contaminated with hemolytic streptococcus *identical* with the type recovered from the throat of the owner Further cultures were made of blankets of 50 Great Lakes men on arrival at Sampson; 40% were positive. At this time cultures were also made of blankets of 50 Sampson men in the Outgoing Unit as they were leaving Sampson; 38% of these blankets were positive for hemolytic streptococcus.

1 *Findings in Three Drafts of Seasoned Personnel on Arrival at Farragut:* This study was made to determine whether there was any relation between the contamination of bedding and the incidence of carriers of hemolytic streptococcus One hundred and seventy-six men and their bedding were cultured.

Of these 176 men, 117 reported from Bremerton, 34 from La Mesa and 25 from Terminal Island. After preliminary statistical analysis, it was observed that the results in personnel from La Mesa and Terminal Island were not significant The results on the men from Bremerton are given in Table 1

Table 1 shows that·

(a) Eighty-five (73%) of 117 healthy men had hemolytic streptococcus in their throat flora

(b) Cultures of dust samples taken from their bedding showed that 79 men (68%) of a possible 117 carried beta hemolytic streptococcus in their blankets and mattress covers or both

streptococci, the dust from the blankets of that person usually yielded positive cultures for hemolytic streptococci.

(c) The most significant streptococcal carriers, from the point of view of spread of contagion, appeared to be men with positive cultures both in the nose and throat. However, the apparent significance of positive nose and throat cultures was not confirmed by the cultural findings. The typing results showed that only three of seven had the same type of hemolytic

TABLE 2

Results of Nose, Throat, and Blanket Cultures on 100 Men in Outgoing Unit

Results	Men with Recent Respiratory Infections		No History of Illness		Total	Percent of Total
	Number	Percent	Number	Percent		
N−, T−, B−	5	22 7	22	28 2	27	27
N+, T+, B−	0	0	1	1 3	1	1
N+, T−, B+	0	0	1	1 3	1	1
N−, T+, B+	4	18 2	14	17 9	18	18
N−, T−, B+	10	45 5	19	24 4	29	29
N−, T+, B−	2	9 1	14	17 9	16	16
N+, T+, B+	1	4 5	6	7 7	7	7
N+, T−, B−	0	0	1	1 3	1	1
Totals	22	100	78	100	100	100

TABLE 3

Results of Nose, Throat, and Blanket Cultures on 100 Men in Outgoing Unit

	Blankets +	Blankets −	Totals
Throat−, Nose−	29	27	56
Throat+, Nose+	7	1	8
Throat+, Nose−	18	16	34
Nose+, Throat−	1	1	2
Totals	55	45	100

streptococcus on the blankets as that identified in their nose and throat cultures. In the other four, the type of hemolytic streptococcus cultured from the blanket differed from that of the nose and throat cultures These findings showed that the organisms from the blankets of the four men in whom the findings did not correlate came from some source other than the nose and throat of the man using the blanket Furthermore, only four of the eighteen men who yielded two positive results (either nose and blanket

The typing results in 53 mattress cover cultures showed that 30 were Group A hemolytic streptococci of various types. However, only 18 of these 30 had the same type of organism on the pharyngeal mucosa and mattress cover. The type of Group A hemolytic streptococci on the mattress cover of 12 men was different from that in the throat flora. In this series, transfer from throat to mattress cover occurred no more often than a chance phenomenon (12 times in 100).

1. *Findings in Men Leaving Farragut.* Dust studies made at Farragut in several groups of men after the termination of recruit training were reported in detail previously. One survey was made to determine whether the bedding of patients with streptococcal respiratory disease was contaminated with Group A hemolytic streptococcus of the same type as carried in the throat. A total of 55 cases was studied. The results were:

55 Throat cultures	55 Positive
52 Cultures of dust from sheets	42 Positive
38 Cultures of dust from blankets	31 Positive
51 Cultures of dust from mattress covers	22 Positive
53 Cultures of dust from mattresses	23 Positive

A second survey was made to determine whether, on detachment, Farragut men carried Group A hemolytic streptococcus to other stations only in the upper respiratory tracts or whether they also carried the same type of Group A hemolytic streptococcus on their bedding. Cultures were taken from the nose and throat of 100 men ready for transfer. Their blankets were shaken and the dust obtained was cultured. Of the 100 men, 22 had had upper respiratory infections within one month of the date the dust specimens were obtained. Sixteen of these 22 men still had upper respiratory infections. The remaining 78 men had escaped upper respiratory tract infections. The results obtained are recorded in Tables 2 and 3. The data cited in Table 2 were analyzed statistically (by application of the formula for significant differences between the observed percentages of positive and negative results in the two categories) and it was found that the differences in the results, between those men ill or recently ill with respiratory infections and those who were not ill could easily have occurred by chance. Therefore, all of these men were considered members of the same universe in Table 3.

The following preliminary impressions were gained from these data:

(a) When either the nose or the throat culture of a man was positive for hemolytic streptococci, there did not appear to be any correlation, statistically, between the results of the upper respiratory tract cultures and the results of cultures from the blankets.

(b) When both the nose and throat cultures were positive for hemolytic

D FACTORS INFLUENCING THE SURVIVAL OF GROUP A HEMOLYTIC STREPTOCOCCUS IN INANIMATE RESERVOIRS

The reservoirs of Group A hemolytic streptococci which may give rise to outbreaks of infection each winter seem to be the human host and dust Hemolytic streptococci commonly disappear from the pharyngeal mucosa of the infected person within one month and from tonsils and accessory sinuses during the summer months However, a few persons remain healthy, chronic carriers for years For example, prior to World War II one of the authors (A F. C) observed that during the summer months in New York City some persons remained carriers but their throat strains lost "mattness" on blood agar plates and were no longer typable by serologic methods How long these organisms survived outside of the human host was not known prior to World War II. Buchbinder (27) found in his simulated room environment that hemolytic streptococci died at a constant percentage rate with few organisms surviving after several weeks Daylight and sunshine accelerated the death rate of hemolytic streptococci. The Navy studies previously described showed that there was great variation in the survival time of hemolytic streptococcus outside of the human host Two determining factors appeared to be the climate and some character of the streptococcal strain. Further observations made on these factors are:

1. *Observations on Humidity in Barrack Dormitories.* No explanation has been made for the prolonged survival of hemolytic streptococci in the floor dust at Farragut, Idaho Windows were ordinarily kept closed during the winter months, the room temperature was usually high, the humidity inside was low, the hours of annual sunlight were less than in most of the States. Observations were made to determine whether inside humidity might be readily modified by the opening of windows, wet swabbing of floors or by placing water pans over the entire length of the 12 radiators in the dormitories of barracks The collected data on temperature and humidity for typical barracks in two camps are given in Table 4

These observations were made at different times of the day in empty barracks and in occupied barracks under normal routine conditions At this time the outdoor relative humidity was 100% and the temperature was 2°C (35°F) The water pans had no significant effect and the opening of windows only a moderate effect on the inside humidity which averaged between 21% and 25% in the sleeping quarters at Farragut Naval Training Center Whether low humidity increases the survival time of hemolytic streptococcus remains to be determined

2 *Observations on the Effect of Solar Heat on Two Farragut Strains of Hemolytic Streptococcus* Two strains of hemolytic streptococcus which had been prevalent at Farragut were used for this test. They were a sulfon-

or throat and blanket positive) had the same type of organism in both the respiratory tract and the blanket. It appeared from these observations that organisms cultured from the blankets reflected the types of hemolytic streptococci prevalent at Farragut N.T.C. in April 1945.

In summary, the mattress covers as well as blankets were reservoirs of Group A hemolytic streptococcus. The degree of contamination of bedding was relatively low in the two groups of men with moderate carrier rates and high in one group with a high streptococcal carrier rate. The source of contamination was not necessarily the man using the bedding. Contamination may have come from other men sharing the same quarters.

C. OBSERVATIONS ON OTHER POSSIBLE RESERVOIRS OF CONTAGION

1. *Eating Utensils* Bacteriologic studies were made of spoons, forks, knives, cups and trays which had come out of washing machines of three camps. In each camp 20 of each kind of utensil were cultured on three occasions. The bacterial counts were less than one hundred per utensil except for a slight elevation on the counts from spoons which because of their shape may have packed together. Hemolytic streptococcus was not recovered. The temperature of the water was 120°F for the washing, 160°F. for the first rinsing and 180°F for the final rinsing. Three ounces of detergent had been added to each washing machine every fifteen minutes.

2. *Coats* A survey was made of the throat flora and coats of 39 men in the Outgoing Unit. In this group 23 had a positive throat culture, six had positive coat dust cultures, four of these were from men with positive throat cultures. Only two had the same type of hemolytic streptococcus on their coats as in their throat flora.

3. *Air Analyses* This study was made to determine whether the positive cultures obtained from blankets and other objects may have come from air contaminants. The apparatus for collecting air samples consisted of a receiving tube containing 10 cc. of peptone water into which a glass bulb pierced with 16 small holes was inserted. A second tube acted as a trap for overflow of the medium. Suction was created by a ¼ horsepower motor. The negative pressure was measured by a water manometer. It was maintained at a level which permitted 20 cubic feet of air to bubble through the medium in 30 minutes. After collection, 1 cc. of each sample was immediately plated on blood agar.

A total of 30 air samples was taken at the same locations from which positive samples of dust were obtained. None contained hemolytic streptococcus.

This observation strengthened the opinion that streptococci cultured from floor dust and bed clothing were in dust and lint and were not air contaminants associated with faulty techniques in making the cultures.

amide sensitive type 3 and a strain which had been classified as type 17 Re 125.

Procedure: Eight mattresses with dust cultures negative for hemolytic streptococcus were placed outdoors in summer sunlight for four hours. The surface of each was divided into 18 areas 1 foot square and separated with adhesive tape. Each area of four mattresses was seeded with type 3 and each area of the other four mattresses was seeded with type 17 Re 125. This was done by spraying a culture with a hand atomizer. The four corner areas of each mattress were covered and served as a control. Cultures were made at half hour intervals on the test areas. The mattress temperatures were recorded during the four hour period of these tests. The average surface temperature for the four mattresses seeded with type 3 was 95°F. and with type 17 Re 125 was 125°F.

Results The type 3 organisms disappeared rapidly. After one-half hour of exposure one third of the mattress areas seeded were sterile, after one hour, two-thirds were sterile; after 1½ and 2 hours, only 1 to 3 colonies were recovered from 2 of 12 areas. In contrast, type 17 Re 125 organisms survived in all areas of the four mattresses seeded. A heavy growth of hemolytic streptococcus was cultured at the end of the experiment from the 16 control areas seeded with type 3 as well as the 16 control areas seeded with type 17 Re 125

The type 3 organisms remained sulfonamide sensitive, but in most instances, the type of the organisms recovered could not be identified after exposure to solar radiation. All cultures of type 17 submitted to a higher temperature than type 3 were readily identified and all cultures were classified either as Re 125 or Re 25

These observations suggested that the Re strain of type 17 was more resistant to solar radiation than the sulfonamide sensitive type 3 strain.

4. *Observations on the Effect of Heat on Five Farragut Strains of Hemolytic Streptococcus* Five Group A cultures (twenty-four-hour growth in tryptose phosphate broth) were sprayed on the surface of glass Petri dishes, dried for twenty-four hours and then exposed to three experimental temperatures in a hot air oven The strains used were type 17 Re 125 (described), type 19 Re 25, and sulfonamide sensitive strains of type 17, 24 and of type 3 (described) Cultures were made at half hour intervals.

A striking difference in viability was observed between these strains on exposure to 85°C The type 24 strain began to die in 15 minutes and was not viable after 90 minutes. The type 17 Re 25 strain began to die in one hour and was not viable at four hours The type 3 strain began to die at 2½ hours and was not viable at four hours. The sulfonamide sensitive type 17 strain began to die at one hour but still was alive at four hours The

TABLE 4

Relative Humidity in Sleeping Dormitories at Farragut Naval Training Center

Date	Time	Area and Barracks	Pans Full	Dry Bulb Temperature	Wet Bulb Temperature	Relative Humidity	Remarks
12 Feb	1030	18A6L	Yes	23°C 73 4°F	12°C 53 6°F	23%–24%	Windows closed and pans filled 0730. Room thermometer 76°F.
12 Feb	1045	18A6U	Yes	22°C 71 6°F	11°C. 51 8°F.	23%–24%	Windows closed and pans filled 0730. Rm therm. 72 F.
12 Feb	1100	18A5L	No pans	20°C 68°F	10°C 50°F	25%	Windows closed at 0730 Rm. therm. 69°F.
12 Feb.	1110	18A5U	No pans	21°C 69 8°F	11°C 51.8°F	27%–28%	Windows closed at 0730 Rm. therm 71°F.
12 Feb	1900	18A5L	Yes	20°C 68°F	10°C 50°F.	24%–25%	Windows open 4", staggered. Rm. therm. 68°F.
12 Feb	1915	18A5U	Yes	22°C 71 6°F	13°C 55 4°F.	32%–31%	Windows open 4", staggered. Rm therm. 72°F.
12 Feb	1920	18A6L	No pans	21°C. 69.8°F	12°C. 53.6°F	28%–29%	Windows open 4"; staggered. Rm. therm 71°F.
12 Feb	1935	18A6U	No pans	23°C. 73 4°F	14°C 57.2°F	34%–35%	Windows open 4"; staggered Rm. therm. 72°F.
15 Feb.	1020	18A1L	Yes	24°C 75°F	12°C 54°F	21%	Windows closed since 0730 Rm. therm. 77°F.
15 Feb	1030	18A1U	Yes	23°C 77°F	12.5°C 55°F	22%	Windows closed since 0730. Rm. therm. 77°F.
15 Feb	1055	18A2L	No pans	24°C 75°F	12°C 54°F	21%	Windows closed since 0745. Rm. therm 79°F.
15 Feb	1110	18A2U	No pans	23 5°C. 74°F.	11.5°C 53°F.	21%	Windows closed since 0745. Rm. therm 74°F.
16 Feb	1950	18A1L	Yes	21°C. 70°F	10°C. 50°F.	22%	Six windows open 3". Decks swabbed 1930. Rm. therm. 69°F.
16 Feb	2000	18A1U	Yes	21°C 70°F	10°C. 50°F.	22%	Six windows open 3". Decks swabbed 1930. Rm. therm. 68°F.
16 Feb	2010	18A2L	No pans	18°C 65°F.	9°C. 47°F.	34%	Four windows open Deck swabbed 1945. Rm. therm 66°F.
16 Feb	2015	18A2U	No pans	20°C. 68°F.	10°C. 50°F.	26%	Six windows open. Deck swabbed 1945. Rm. therm. 68°F.

amide sensitive type 3 and a strain which had been classified as type 17 Re 125

Procedure: Eight mattresses with dust cultures negative for hemolytic streptococcus were placed outdoors in summer sunlight for four hours. The surface of each was divided into 18 areas 1 foot square and separated with adhesive tape. Each area of four mattresses was seeded with type 3 and each area of the other four mattresses was seeded with type 17 Re 125. This was done by spraying a culture with a hand atomizer. The four corner areas of each mattress were covered and served as a control. Cultures were made at half hour intervals on the test areas. The mattress temperatures were recorded during the four hour period of these tests. The average surface temperature for the four mattresses seeded with type [illegible]

hour, two-thirds were sterile; after 1½ and 2 hours, only 1 to 3 colonies were recovered from 2 of 12 areas. In contrast, type 17 Re 125 organisms survived in all areas of the four mattresses seeded. A heavy growth of hemolytic streptococcus was cultured at the end of the experiment from the 16 control areas seeded with type 3 as well as the 16 control areas seeded with type 17 Re 125.

The type 3 organisms remained sulfonamide sensitive, but in most instances, the type of the organisms recovered could not be identified after exposure to solar radiation. All cultures of type 17 submitted to a higher temperature than type 3 were readily identified and all cultures were classified either as Re 125 or Re 25

These observations suggested that the Re strain of type 17 was more resistant to solar radiation than the sulfonamide sensitive type 3 strain.

4. *Observations on the Effect of Heat on Five Farragut Strains of Hemolytic Streptococcus*· Five Group A cultures (twenty-four-hour growth in tryptose phosphate broth) were sprayed on the surface of glass Petri dishes, dried for twenty-four hours and then exposed to three experimental temperatures in a hot air oven [illegible] d), type 19 [illegible] type 3 (des [illegible]

A striking difference in viability was observed between these strains on exposure to 85°C. The type 24 strain began to die in 15 minutes and was not viable after 90 minutes. The type 17 Re 25 strain began to die in one hour and was not viable at four hours The type 3 strain began to die at 2½ hours and was not viable at four hours. The sulfonamide sensitive type 17 strain began to die at one hour but still was alive at four hours. The

TABLE 4

Relative Humidity in Sleeping Dormitories at Farragut Naval Training Center

Date	Time	Area and Barracks	Pans Full	Dry Bulb Temperature	Wet Bulb Temperature	Relative Humidity	Remarks
12 Feb	1030	18A6L	Yes	23°C 73.4°F	12°C 53.6°F	23%–24%	Windows closed and pans filled 0730. Room thermometer 76°F.
12 Feb	1045	18A6U	Yes	22°C 71.6°F	11°C 51.8°F.	23%–24%	Windows closed and pans filled 0730. Rm. therm. 72 F.
12 Feb	1100	18A5L	No pans	20°C 68°F.	10°C. 50°F.	25%	Windows closed at 0730. Rm. therm. 69°F.
12 Feb	1110	18A5U	No pans	21°C 69.8°F.	11°C 51.8°F.	27%–28%	Windows closed at 0730. Rm. therm. 71°F.
12 Feb	1900	18A5L	Yes	20°C 68°F	10°C 50°F	24%–23%	Windows open 4"; staggered. Rm. therm. 68°F.
12 Feb	1915	18A5U	Yes	22°C 71.6°F.	13°C. 55.4°F	32%–31%	Windows open 4", staggered. Rm. therm. 72°F.
12 Feb	1920	18A6L	No pans	21°C 69.8°F	12°C. 53.6°F	28%–29%	Windows open 4", staggered. Rm. therm. 71°F.
12 Feb.	1935	18A6U	No pans	23°C 73.4°F.	14°C. 57.2°F	34%–35%	Windows open 4", staggered. Rm. therm. 72°F.
15 Feb	1020	18A1L	Yes	24°C. 75°F.	12°C. 54°F.	21%	Windows closed since 0730. Rm. therm. 77°F.
15 Feb.	1030	18A1U	Yes	23°C 77°F	12.5°C. 55°F	22%	Windows closed since 0730. Rm. therm. 77°F.
15 Feb	1055	18A2L	No pans	24°C 75°F	12°C. 54°F.	21%	Windows closed since 0745. Rm. therm. 79°F.
15 Feb	1110	18A2U	No pans	23.5°C 74°F.	11.5°C. 53°F.	21%	Windows closed since 0745. Rm. therm. 74°F.
16. Feb.	1950	18A1L	Yes	21°C. 70°F	10°C. 50°F.	22%	Six windows open 3". Decks swabbed 1030. Rm. therm. 69°F.
16 Feb.	2000	18A1U	Yes	21°C 70°F	10°C. 50°F.	22%	Six windows open 3". Decks swabbed 1930. Rm. therm. 68°F.
16 Feb.	2010	18A2L	No pans	18°C. 65°F.	9°C. 47°F.	34%	Four windows open. Deck swabbed 1915. Rm. therm. 66°F.
16 Feb.	2015	18A2U	No pans	20°C 68°F.	10°C. 50°F.	26%	Six windows open. Deck swabbed 1915. Rm. therm 68°F.

gerous carrier gave rise to infections on transfer from the hospital to a barrack. There can be little doubt that the apparently healthy host may initiate streptococcal outbreaks Furthermore, it was shown at Farragut that streptococci sprayed into the air for experimental purposes infected the sprayer in spite of strict precautions The collected observations indicate that hemolytic streptococcus can cause infections of the upper respiratory tract when released from either an animate or an inanimate reservoir.

The accumulated evidence of other observers would seem to indicate that among the animate reservoirs, the nasal carrier of hemolytic streptococcus disperses the largest number of these organisms (28). Other things being equal, the actuarial risk of infection might well be determined by the quantity of bacteria inhaled However, other things are not equal. There is great variation in the communicability and pathogenicity of streptococcal strains In the present studies it has been shown that the introduction of a single highly pathogenic and communicable strain caused an epidemic among men who had escaped infection while living in an environment seeded with many organisms of Group A hemolytic streptococcus.

SUMMARY

These findings showed that the degree of streptococcal contamination of an inanimate reservoir paralleled the incidence of carriers or infected persons.

When the throat carrier rate was high at Farragut, floor dust and bedding were found to be heavily contaminated However, when this Training Center of 50,000 men was converted to an Activity with 5,000 relatively fixed personnel, the throat carrier rate fell to 8% and the incidence of hemolytic streptococcal cultures fell to 4% in mattresses, and 0% in blankets and floor dust

Furthermore, at other Naval Training Centers with a rapid turnover of personnel, the sharp fall in incidence of streptococcal infections and carrier rates during the summer months was accompanied by the disappearance of Group A hemolytic streptococcus from the floor dust

It appeared that the inanimate reservoirs were, with one exception, dependent upon the animate reservoirs for reseeding At Farragut, the degree of contamination of floor dust remained unchanged for at least six months without reseeding

An attempt to detect the persons most likely to contaminate their blankets showed that the most significant carriers were men with positive cultures both in the nose and throat However, it was shown that the serologic types of organisms recovered from blankets and mattress covers reflected the strains prevalent in the group rather than the strains carried by the owner Streptococcal contamination of bedding was associated with

type 17 Re 125 strain was unaffected by four hours' exposure to 85°C. in this hot air oven.

The thermal death point of this type 17 Re 125 strain was higher than the other Farragut strains tested. Furthermore, it showed survival characteristics at atmospheric temperatures. Of the many sulfonamide resistant strains of hemolytic streptococcus recovered in November, 1944, this was the only Re strain still present one year later in the throat flora of Farragut personnel.

E. DISCUSSION

The lack of a suitable experimental animal precludes estimation of infectivity of hemolytic streptococcus as a pathogen of the upper respiratory tract. This makes it impossible to determine whether Group A hemolytic streptococci recovered from the throat flora are more or less communicable than the contaminants of the air, floor dust or bedding. Furthermore, information is lacking on the important point, the relative susceptibility of man to direct infection from a human contact, compared with indirect infection from inhalation of contaminated particulate matter. The present report indicates that there is a close association between animate and inanimate reservoirs of Group A hemolytic streptococcus, but does not indicate which is more important in the initiation of streptococcal infections.

Serial observations on the throat flora of Naval personnel showed that Re strains of hemolytic streptococcus were carried for at least three months at Farragut, Idaho. No changes were detected in these organisms during this period. Prior to World War II it was observed that persons in New York City carried Group A hemolytic streptococcus in their throat flora over a period of years These organisms lost their "mattness" and typeability during the summer months, however, with the return of cold weather the organisms' original type was readily identified. In most instances, these chronic carriers gave rise to no secondary infections. However, in some instances, after the carrier contracted a "common cold," he changed from a harmless to a "dangerous carrier" Whether the dangerous carrier or objects contaminated by him initiated secondary infections was unknown.

Observations made in the Navy during World War II have shown that a single streptococcal carrier, upon transfer to another station, may initiate a streptococcal outbreak caused by the strain carried in the throat flora. In these instances, the new environment received not only a carrier but also contaminated bedding and clothing When, however, Naval personnel were transferred from a barrack to a hospital, or from a hospital to a barrack, the man and his contaminated belongings were separated. Under these conditions it was shown that the dangerous carrier gave rise to cross-infections on arrival in the hospital wards and that the convalescent dan-

CHAPTER XVII

THE REMOVAL OF CONTAMINATED DUST RESERVOIRS

Effect on the Spread of Streptococcus Hemolyticus

It had appeared that there were at least two sources from which the streptococcal infections at Training Centers probably stemmed. These were: first, older recruits infected with or carrying hemolytic streptococcus in the naso-pharynx, second, contaminated particles of floor dust and blanket lint A preliminary study in which these two factors were largely eliminated was made at Farragut Naval Training Center. Extensive studies were made at Great Lakes to determine what effect the elimination of these reservoirs of contamination might have on the epidemic spread of hemolytic streptococcus The findings at these two stations were:

A. OBSERVATIONS AT FARRAGUT

An epidemic caused by sulfonamide resistant type 17 organisms occurred during the summer of 1944 in Camp Peterson. Two weeks after the epidemic had reached its peak the camp was closed For one week in October the camp was unoccupied, the buildings were aired and cleaned The camp was then filled with fresh recruits, new bedding was issued. These men were not exposed to contaminated lint from blankets which had been in use nor were they exposed to other recruits. However, they were exposed to the station's medical personnel in the dispensaries and to the Ship's Company in the dining hall The changes which were observed in the epidemic pattern of streptococcal infections at Camp Peterson are shown in Figure 1

It is seen in Figure 1 that. Streptococcal infections occurred, the incidence, though lower than it had been during the epidemic, was abnormally high for the fall [illegible]

[illegible]

a resistant type 19 organism during the last four weeks of training The prevalence of this Re strain was increasing progressively when training ended and the camp was closed This type 19 resistant strain was prevalent in other camps of the Center and had been prevalent among the station personnel The probable source of this organism in Camp Peterson was station personnel The floor dust of the dispensary which, though cleaned, had not been decontaminated, may have harbored type 19 as well

the incidence of carriers or infected persons in the group but did not reflect the infection of the owner.

Maintenance of animate and inanimate reservoirs of hemolytic streptococcus appeared to be determined, in part at least, by the capacity of the microorganism to survive. In November, 1945, the only Rc strain of hemolytic streptococcus still present at Farragut was type 17 Rc 125 This organism showed unusual capacity to withstand prolonged solar radiation at a temperature of 125°F. and to withstand four hours' exposure to 85°C. in a hot air oven after having dried for twenty-four hours at about 37°C.

In brief, it appeared that both animate and inanimate reservoirs of hemolytic streptococci were sources of contagion, that they were as closely associated as the "chicken and the egg" and that the relative importance of each may be determined by survival characteristics of the prevalent streptococcal strains under varying climatic conditions.

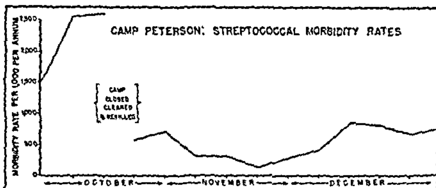
B OBSERVATION AT GREAT LAKES NAVAL TRAINING CENTER

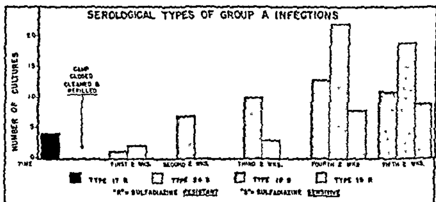
Studies were made in the spring months of 1945 at Great Lakes to determine the effect of removing contaminated dust reservoirs on the incidence of streptococcal diseases At this time a streptococcal epidemic was at its height, the majority of Great Lakes infections were being caused by Re strains of types 17, 19 and 3.

1. *A Comparison of Companies Admitted to "Clean" and "Unclean" Camps* Two companies were selected in March, 1945 from one group of men upon their arrival for recruit training. Neither carried the epidemic strains in the throat flora One company was placed in Camp Moffett where the interiors of buildings had been aired, washed and treated with oil This was classified as a "clean" camp. The other company was placed in Camp Dewey where the routine techniques for sweeping and polishing floors were continued This was classified as an "unclean" camp. Each company under observation included 140 men with the same streptococcal carrier rate The "clean" company was issued oiled blankets Men in the company with positive throat cultures were segregated in one part of the barrack until a subsequent culture proved negative for hemolytic streptococcus. Throat cultures and clinical observations were made weekly of each man of these two companies The Group A streptococci cultured were tested for type and sulfonamide resistance. The difference in the incidence of streptococcal diseases between these two companies was striking. The "clean" company had three streptococcal illnesses The carrier rate remained less than 3% throughout training Two of the three infections were caused by the epidemic type 17 Re 125 strain The "unclean" company was handled in routine manner As its members became sick, its complement was filled with recruits who had been discharged from the scarlet fever wards Six of twelve men added to this company were carriers of Re epidemic strains of types 17 and 3. Streptococcal illnesses began in the second week with three infections and the incidence rose progressively Seventeen of these 140 men were admitted to the wards with streptococcal infections due to Re strains of types 17 and 3 Three of them had scarlet fever During this short period the streptococcal carrier rate rose each week 8%, 10%, 11%, 17%, and 24% This company was transferred to another Naval Activity in the seventh week at a time when its personnel were most likely to disseminate hemolytic streptococcus The "clean" company remained at Great Lakes during this seventh week, had no streptococcal infections and a throat carrier rate of less than 1%

In summary, these observations showed. (a) that the strains which caused infections in these two companies were acquired at Great Lakes and not introduced by the new recruits, (b) that the methods used during epidemic periods did not eliminate infection with an epidemic strain, (c) that by minimizing the exposures to contaminated dust and convalescent carriers,

CLINICAL & BACTERIOLOGICAL OBSERVATIONS
AFTER RE-OPENING CAMP PETERSON FARRAGUT NTC





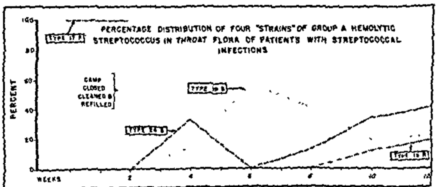


Fig 1. Changes Observed after Cleaning and Refilling a Navy Camp

as the epidemic type 17. This type 19 Re strain spread rapidly among Camp Peterson recruits.

Camp Dahlgren (Regiment 21)

Respiratory Disease Admission Rate: The rate rose to 500 in the first week and then climbed progressively to 1400 during the seventh week.

Scarlet Fever Rate: The first case occurred on the tenth day. It was caused by hemolytic streptococcus type 17 Re 125, and all subsequent streptococcal infections were caused by this epidemic strain. The morbidity rate rose slowly and progressively to 300 in the seventh week. For the seven weeks prior to this study the scarlet fever morbidity rates had been: 1800, 1300, 1100, 700, 800, 700 and 700.

Camp Decatur (Regiment 23)

Respiratory Disease Admission Rate: The morbidity rate rose to 500 in the first week and 1500 at the end of the fifth week.

Scarlet Fever Rate: The first streptococcal infection occurred on the fourth day, however, the epidemic strain, type 17 Re 125, did not appear until the third week. Subsequently this strain was responsible for all streptococcal infections. The scarlet fever rate climbed to a level of 200 where it remained stationary. Scarlet fever morbidity rates for the seven weeks prior to this study had been: 200, 400, 600, 700, 500, 500 and 500.

Camp Hull (Regiment 25)

Respiratory Disease Admission Rate: The morbidity rate rose to 500 in the first week and to a peak of 1600 in the third week.

Scarlet Fever Rate: The first streptococcal infection which occurred one week after the camp was opened was caused by the epidemic strain type 17 Re 125. Subsequent infections were due to this organism, to another epidemic strain, type 3 Re 5, and to several sulfonamide sensitive organisms. The morbidity rate rose progressively to 300 in the seventh week. Scarlet fever morbidity rates for the seven weeks prior to this study had been approximately: 1300, 1100, 1300, 700, 1000, 800 and 600.

Camp McDonough (Regiment 27)

Respiratory Disease Admission Rate: The morbidity rate reached 250 at the end of the first week and rose progressively to 1850 in the seventh week.

Scarlet Fever Rate: Streptococcal infections began in the first week. They were caused by two epidemic strains, type 17 Re 125 and type 3 Re 5. The rate remained below 100 until the seventh week when it climbed to 300. Scarlet fever morbidity rates for the seven weeks prior to this study had been: 1400, 1100, 1200, 800, 1000, 800 and 500.

Camp Mahan (Regiment 29)

Respiratory Disease Admission Rate: The morbidity rate rose from 100 in the first week to 2900 in the seventh week.

Scarlet Fever Rate: Scarlet fever occurred on the tenth day and was caused by an epidemic strain, type 3 Re 5, which subsequently became prev-

it was possible to maintain a normal carrier rate and low incidence of streptococcal diseases; (d) that failure to modify exposure to contaminated dust and convalescent carriers resulted in the loss of 12% of men from streptococcal infections in five weeks and a high throat carrier rate at the time that these recruits were seeded into other Naval Activities.

2. *Clinical and Bacteriologic Findings in Eight Camps "Cleaned" and Refilled in Succession:* Eight camps at the Great Lakes Naval Training Center were emptied between the last week of February and the second week of April, 1945. All buildings were aired and cleaned; the walls and floors were oiled; blankets were oiled prior to being issued to men arriving from civilian life; about 5,000 men, on arrival each week, were assembled in the Receiving Barracks (Camp Barry) and then admitted to the clean camp. Patients who contracted tonsillitis, scarlet fever or other streptococcal diseases requiring hospitalization were sent upon recovery to the uncleaned Camp Maury.[1] Station personnel, including physicians, dentists, corpsmen, Ship's Cooks and Ship's Company working in the Recreation Building, were not changed. The order of emptying and refilling one camp each week was.

Moffett (Regiment 14), Dahlgren (Regiment 21), Decatur (Regiment 23), Hull (Regiment 25), McDonough (Regiment 27), Mahan (Regiment 29), Downes (Regiement 10), Dewey (Regiment 12). This operation was executed during a severe epidemic of streptococcal infections at a time when a continuance of high morbidity rates was to be expected. The clinical observations made after these camps were cleaned and refilled were:

Camp Moffett (Regiment 14)

Respiratory Disease Admission Rate The morbidity rate rose to almost 500 during the first week and then climbed progressively to 1400 at the end of the seventh week

Scarlet Fever Rate Scarlet fever occurred on the day the camp was opened The rate rose slowly but progressively to approximately 300 during the final week These infections were caused by the epidemic strain, type 17 Re 125 The origin of these infections was in Company 298 which had been in the Receiving Barracks (Camp Barry) for five days One man in this company had scarlet fever (type 17 Re 125) on arrival at Camp Moffett This organism spread to men in the company and in other companies of the camp, however, epidemic conditions did not develop

Scarlet fever morbidity rates for the seven weeks prior to the institution of these procedures had been approximately. 200, 450, 1250, 1800, 1250, 850, and 600. Following cleaning the rates varied from 100 to 300.

[1] This procedure was carried through when the first four camps were cleaned. After that scarlet fever convalescents were returned to companies in which scarlet fever had occurred

scarlet fever in the eight camps which had been cleaned. Figure 3, upper, shows the relative morbidity rates for upper respiratory tract infections and for scarlet fever by week of training; and Figure 3, lower, gives the weekly morbidity rates for upper respiratory tract infections and for scarlet fever in each of the cleaned camps

It is seen that the morbidity rates were highest in Camp Mahan during *the period of study. This was the only camp which was not segregated.* Intermingling of men occurred with the recruits of Camp Maury which

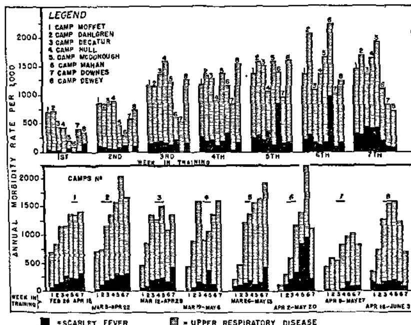


FIG 3 Morbidity Rates for Week in Training and for Camp during an Epidemic Period

was not cleaned and which had average scarlet fever morbidity rates of over 1000 throughout February, of over 1200 throughout March and of over 800 throughout April There was opportunity for cross-infections to occur between men of these two camps The lowest rates occurred in the last two camps to be emptied These camps were not cleaned until April when the incidence of respiratory tract infections was beginning to wane.

It is clear that the cleaning of these camps, the oiling of floors, walls and blankets, the filling of a camp on one day and the isolation of recruits at Sick Call did not prevent the introduction of epidemic streptococcal

alent in this camp. The rate rose from 100 in the second week *to 900 in the sixth week*. Scarlet fever morbidity rates for the seven weeks prior to this study had been: 1200, 700, 700, 700, 700, 500 and 300. This high morbidity rate in Camp Mahan is discussed below.

Camp Downes (Regiment 10)

Respiratory Disease Admission Rate: The monthly rate rose from 300 in the first week to 1000 in the sixth week.

Scarlet Fever Rate: Scarlet fever occurred during the first week; however, the maximum rate reached was only 100 in the fifth week. Scarlet fever

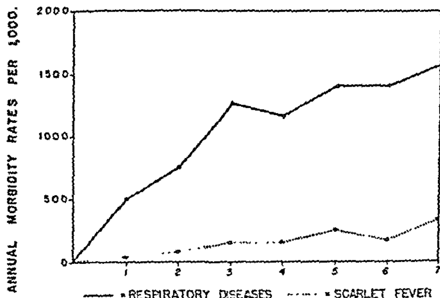


FIG 2 Morbidity Rates for Respiratory Tract Infections and Scarlet Fever after Camps Were Emptied, Cleaned and Refilled

morbidity rates for the seven weeks prior to this study had been 700, 900, 1400, 1000, 600, 500 and 400

Camp Dewey (Regiment 12)

Respiratory Disease Admission Rate The morbidity rate rose from 300 in the first week to 1600 in the fifth week.

Scarlet Fever Rate In the first week scarlet fever reached a rate of 100 and did not exceed this level in subsequent weeks. Scarlet fever morbidity rates for the seven weeks prior to this study had been approximately 200, 400, 400, 500, 500 and 400

A summary of these findings is shown in Figures 2 and 3. Figure 2 gives the average morbidity curves for upper respiratory tract infections and for

Lakes and not by strains introduced by men on arrival from civilian life. Whether the oiling of floors, walls and blankets modified the spread of highly communicable strains was not proved However, it was shown that after the removal of reservoirs of contaminated dust particles, infections were initiated through seeding scarlet fever convalescents into recruit companies

C CONTROLLED OBSERVATIONS AT TREASURE ISLAND ON THE PRACTICAL APPLICATION OF OILING AS A PREVENTIVE MEDICAL MEASURE

The effect of removing reservoirs of contaminated dust particles by oiling floors and blankets was tested during the spring and summer months of 1945 This investigation was undertaken as a cooperative enterprise by U. S Naval Medical Research Unit #1, Berkeley, California and Epidemiology Unit #82, U. S Naval Hospital, Treasure Island, California The problem was to determine the practical effectiveness of an oil-Roccal emulsion in reducing the bacterial content of air, dust and bedding, and in the prevention of respiratory tract infections in a group of enlisted men

The group chosen occupied the Radio Materiel School, located on Treasure Island, California The personnel selected were 2,400 enlisted men who remained for a period of six months in the barracks to be studied Three barracks were chosen as experimental barracks, and three similar barracks served as controls. In the experimental barracks the floors were treated with an emulsion of Roccal and oil three times during the first month of study, then twice monthly for two months and once a month thereafter The blankets of each man residing in or transferred to an oiled barracks were impregnated with a Roccal oil emulsion The amount of oil added per blanket was equivalent to 2 5% by weight of the blanket. Several studies were made:

1. Air sanitation observations:

(a) Air samples by the exposed blood agar plate method

(b) Recovery of hemolytic streptococci from dust samples.

2. Studies on the bacterial content of blankets following treatment with oil-Roccal solution.

3 The control of respiratory diseases

(a) Morbidity rates for minor respiratory complaints based on dispensary and hospital admissions from oiled and unoiled barracks

(b) Rates for more serious respiratory disease based on dispensary and hospital admissions from oiled and unoiled barracks

(c) Carrier rates for hemolytic streptococci in oiled and unoiled barracks.

The results of the first six months of this study were.

1. Air Sanitation:

strains. Careful and exhaustive efforts were made to trace the origin of these strains Food, gas masks, swimming pools and dental examinations were eliminated as possible sources. Some infections were shown to be introduced by men who were contaminated in the Receiving Barracks after arrival at Great Lakes but prior to entry into a clean camp. Another probable source was Ship's Company. For example, 25% of the medical personnel and 30% of the dining hall personnel in Camp Moffett proved to be carriers of epidemic Rc strains. The same strains were present in the throat flora of medical personnel in other camps; e.g., Dahlgren 15%, and Hull 15%. In striking contrast they were not present in the throat flora of dental personnel[3]

It was not practicable to make a study in which only one preventive measure was introduced into each camp. However, it was shown that the oiling of floors in Camp Maury, which received most of the scarlet fever convalescent patients, had no effect on the scarlet fever morbidity rates. These rates for the four weeks prior to oiling were: 1400, 1100, 800 and 1300; and for the four weeks following oiling were: 1300, 1700, 1300 and 1300.

The weekly respiratory disease rate in uncleaned camps fluctuated between 1800 and 2800 in February and March, was about 1500 in April and 1200 in May. Men in the cleaned camps contracted these minor infections, and by the seventh week the morbidity rates were of this high degree. However, the weekly average scarlet fever rates remained at about the low level of 100 in the clean camps, with the exception of Camp Mahan, during a period when the weekly average scarlet fever morbidity rates in uncleaned recruit camps was over 1,000

In summary, these observations at Great Lakes Naval Training Center showed that the wide dissemination of highly communicable strains of hemolytic streptococcus during an epidemic militates against the interruption of an epidemic process During a season in which respiratory diseases were prevalent and a streptococcal epidemic was in progress, the introduction of epidemic strains could not be prevented by the control measures tested; however, the epidemic process was modified.

Newly arrived civilians were infected in the Receiving Barracks. The effectiveness of dust control measures was materially reduced when there was close contact between personnel in clean and unclean camps Recruits were exposed to carriers of the epidemic strains when visiting medical personnel in their camp dispensaries.

The large majority of streptococcal infections occurring in the clean camps was caused by the highly communicable strains epidemic at Great

[3] This observation is in accord with the findings at San Diego where dental officers escaped scarlet fever during an epidemic

These blankets were then treated with an oil emulsion and Roccal in the Ship's Service laundry. They were retested prior to reissue to their owners

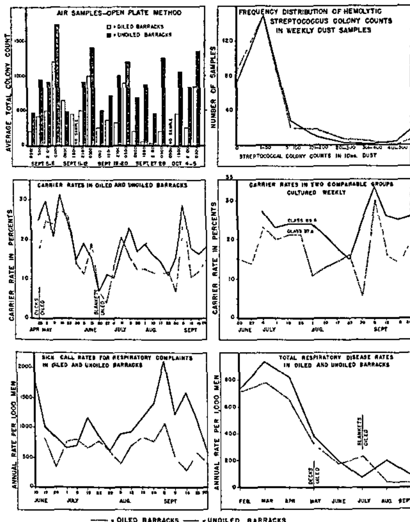


FIG 4 The Failure of Oiling Barrack Floors to Reduce Appreciably Respiratory Disease Rates

and once a month thereafter A similar group of blankets, used as a control, was sampled and then washed in the routine laundry manner but not

(a) Air Samples: Several methods for studying the bacterial content of air were tested. The exposed plate method was found to be the simplest method for analyzing effectively the bacterial content of air. Blood agar plates prepared in the usual manner were placed around barracks—four above head level on top of lockers and six at floor level in different parts of a room. These plates were exposed for six hours over a twenty-four hour period. The hours of exposure were 900–1500 (morning); 1500–2100 (afternoon and evening); 2100–0300 (night); 0300–0900 (early morning sweeping). Total colony counts on each plate were made after twenty-four hours' incubation and the results for each barracks were averaged. The results are shown in Figure 4. This chart shows that the bacterial content of air in oiled barracks was at least 50% less than in the unoiled barracks and that this reduction was even greater in the period immediately following the application of oil.

(b) Recovery of hemolytic streptococci from samples of floor dust: Each Monday a sample of the morning sweeping was brought to the laboratory. One gram of dust was placed in 100 cc. of sterile, physiologic salt solution, shaken well and 1 cc. of this mixture plated in a blood-agar pour plate containing 1:1,250,000 gentian violet. After twenty-four hours a count was made of the number of streptococcal colonies showing beta hemolysis. Dust samples were collected at weekly intervals over the period March–October 1945. Altogether 708 counts were made The frequency distribution of these hemolytic streptococcal dust counts is shown in Figure 4 There was no significant difference between the number of organisms isolated from the oiled dust and the number from the unoiled dust. However, much less dust collected in the oiled barracks and at times it was difficult to collect enough material for analysis from the oiled barracks It appeared that the oil held and concentrated the dust and that the Roccal killed some of the organisms with the result that the distribution of colony counts was about the same in dust from oiled and unoiled barracks.

2 *Studies of the Bacterial Content of Blankets Following Treatment with Oil-Roccal Solution·*

One hundred and fifty blankets belonging to 75 men newly admitted to the Radio Materiel School were tested for their bacterial content by means of a Portable Field Device The portable field device sampled the number of organisms released from an area approximately equivalent to that of a Petri dish. The procedure for actual testing was identical for the experimental and control blankets The method consisted of dropping a weight from a fixed height upon a designated area of stretched blanket. The liberated organisms were collected upon the Petri dish with blood agar placed at a fixed distance from the blanket The weight, the stretched blanket, and the Petri dish were enclosed in a specially constructed cylinder

In summary, the oiling of floors and blankets at Treasure Island produced a 50% reduction in the number of bacteria in the air as determined by the exposed plate method. Although there was no significant reduction in the number of hemolytic streptococci isolated from the dust of oiled barracks the amount of dust in these was markedly reduced. Streptococcal carrier rates in oiled and unoiled barracks closely approximated one another during the period of this study when the incidence of respiratory disease was low. Studies on the bacterial content of blankets following treatment with oil-Roccal solution showed that oiling resulted in a tremendous reduction in the number of hemolytic streptococci which were recovered from blankets and that this effect persisted for a long period of time. There was a moderate reduction in the number of Sick Call visits for mild respiratory complaints from personnel in oiled barracks compared with personnel in the unoiled barracks. The morbidity rates for more serious respiratory disease, based on admissions to the dispensary, were about the same for the two groups The streptococcal carrier rates were also approximately equal in the two groups.

SUMMARY

These three sets of observations indicate that both human and dust reservoirs of hemolytic streptococcus contributed to the epidemic spread of this bacterium within Naval barracks.

The elimination of dust reservoirs by the oiling of blankets and floors lowered the bacterial count of blankets and of the barracks air but did not cause a significant reduction in the number of streptococcal infections when exposure to human reservoirs was great.

It was not possible to eliminate exposure to human carriers during an epidemic period. However, when this exposure was reduced to a minimum and dust reservoirs were removed, streptococcal morbidity rates showed a striking reduction

In this study, it appeared that exposure to infected men and convalescent carriers was probably the most important factor in the genesis of streptococcal outbreaks.

treated with the oil-Roccal solution. These blankets were resampled prior to being issued to their owners and once a month thereafter.

The results were as follows:

Total Number of Organisms Obtained (Average of about 150 Blankets) Using PFD

	Before Treatment or Washing	Immediately After Treatment or Washing	One Month After	Two Months After	Three Months After
Experimental	490	8	36	59	56
Control	517	11	435	1000+	645

3. *The Control of Respiratory Tract Disease.*

(a) Every man reporting to daily Sick Call for any reason filled out a Sick Call slip which included his name, class, barracks and the nature of his complaint. These records were analyzed weekly and those listing respiratory complaints were tabulated according to barracks. The results are shown in Figure 4

The morbidity rate was significantly higher in the unoiled barracks. During the week of September fifth, there was a marked increase in minor respiratory illness. This small respiratory disease outbreak occurred chiefly in the unoiled barracks.

(b) Morbidity rates for the more serious respiratory diseases were obtained from the daily reports of the sick to the Treasure Island dispensaries. The admissions slips were tabulated according to disease and barracks. Figure 4 shows the total respiratory disease rates (which included catarrhal fever, tonsillitis and pharyngitis, scarlet fever, pneumonia, rhinitis and bronchitis) in the oiled and unoiled barracks. During the period from May to September the rates for respiratory diseases were low and there was no significant difference between the morbidity rates in the oiled and unoiled barracks

(c) Each week 300 throat cultures (50 per class) were taken from six classes of men who had been in the school comparable periods of time. Three classes were from oiled barracks and three from unoiled barracks. These men were cultured once a month Weekly carrier rates were made of two classes who had entered the school at approximately the same time. One class was from oiled barracks and the other from unoiled barracks The results of these studies are shown in Figure 4.

The weekly carrier rate study showed that the class living in the unoiled barracks maintained a persistently higher rate for hemolytic streptococcus than the class living in the oiled barracks. However, the combined carrier rates for the two studies in oiled and unoiled barracks were about the same during the period of this study.

known to be rheumatic subjects Knowledge was lacking on the relation of rheumatic fever to streptococcal infections among large numbers of persons who had not previously manifested rheumatic phenomena. World War II afforded opportunity to collect this information.

Approximately 2 percent of the entire population of the United States served in the American Navy during World War II. Nearly all of these personnel received indoctrination in one of the Recruit Training Centers Most of them were males between the ages of eighteen and twenty-one Persons who had already manifested rheumatic susceptibility either by developing stigmata of rheumatic heart disease or by a history of recurrent rheumatic attacks were, in most instances, screened before enlistment However, a large percentage of these young men came from areas where exposure to streptococcal infections was minimal Because of this, their susceptibility to rheumatic fever had not been severely tested prior to recruit training. On the other hand, in Naval Training Centers they were exposed to and did contract Group A streptococcal infections in high incidence. More than 20,000 cases of rheumatic fever followed these infections Observations on the relations of these infections "in the herd" to outbreaks of rheumatic fever were made during four periods· first, when streptococcal infections were prevalent and sulfonamides were used therapeutically but not as a prophylactic agent, second, when sulfonamide sensitive strains of hemolytic streptococci were prevalent and when sulfonamides were used not only therapeutically but also as a prophylaxis for respiratory tract infections in several recruit training groups, third, when sulfonamide resistant strains of hemolytic streptococci were prevalent and sulfonamides were used both in therapy and prophylaxis, fourth, when sulfonamide sensitive and resistant strains were prevalent, when no prophylaxis was used and when penicillin therapy had largely replaced sulfonamide therapy Observations made during these four periods serve to indicate the U S Navy experience on the relation of rheumatic fever to streptococcal epidemics during World War II.

A OBSERVATIONS ON THE ASSOCIATION OF RHEUMATIC FEVER WITH STREPTOCOCCAL NASOPHARYNGITIS

1. *Time Relations* Throughout each year of the war there was a striking seasonal rise in the incidence of streptococcal infections from a minimum in August to a peak at the end of the winter months Each year the morbidity curves for rheumatic fever followed the curves for streptococcal throat infection and reached peak incidence about one month after the peak of scarlet fever This relation for the entire Navy in 1945–47 is shown in Chapter II, Figure 2b and for illustrative Training Centers in Figure 1.

2. *Geographical Relations* Through each year of the war the epidemic

CHAPTER XVIII

OBSERVATIONS ON THE RELATION OF RHEUMATIC FEVER TO THE EPIDEMIOLOGY OF STREPTOCOCCUS HEMOLYTICUS

The collected evidence of the past two decades has indicated that hemolytic streptococcal infections of the upper respiratory tract initiate attacks of rheumatic fever in certain persons. Studies of these respiratory tract pathogens have shown that the infecting organisms are characteristically of Group A, that they may be of any serologic type, but that all strains of a serologic type may not induce rheumatic fever. That the "rheumatogenic factor" is a strain characteristic now seems indisputable Furthermore, it has been observed by one of the authors (A F. C.) that one strain of a serologic type may cause an outbreak of throat infections among rheumatic subjects without initiating rheumatic attacks and another strain of the same serologic type of Group A hemolytic streptococcus may cause a similar outbreak of infections among the same subjects with a high incidence of rheumatic attacks What the "rheumatogenic" substance may be is unknown Further observation has shown that bacterial strains highly effective in initiating rheumatic fever are strong erythrogenic toxin producers, whereas the ineffective strains are generally weak toxin producers What significance there may be in this parallelism remains to be defined. Some state of the host appears to determine whether a rheumatic attack occurs after infection with a "rheumatogenic" strain of hemolytic streptococcus. This state of susceptibility also remains unidentified. However, since no laboratory animal has been found in which rheumatic fever occurs spontaneously or in which it has been induced, observations on the relations or rheumatic attacks to hemolytic streptococcal infections have been limited to Man These observations—clinical, bacteriologic, immunologic, biochemical and pathologic—have shown that the rheumatic attack occurs after a susceptible host acquires an upper respiratory tract infection with a "rheumatogenic" strain of Group A hemolytic streptococcus *Furthermore, during the last decade it has also been shown that* when Group A hemolytic streptococcal infections are prevented by daily prophylactic doses of sulfonamide, the initiation of the rheumatic process is also prevented even though the host who is susceptible to rheumatic fever may acquire many other diseases of a viral or bacteriologic nature Studies prior to World War II, though carefully controlled, were of necessity limited to small groups of persons and in most instances limited to groups

occurred at Recruit Training Centers in Northern states It was noted, however, that some Training Centers in the South had outbreaks of streptococcal infections each winter, and that these outbreaks were followed by a high incidence of rheumatic fever. Other Centers with a low incidence of streptococcal throat infections each winter had a low incidence of rheumatic fever throughout the war years. Furthermore, studies at Treasure Island, San Francisco, showed not only that the prevalence of rheumatic fever paralleled the incidence of scarlet fever but also that the acute rheumatic

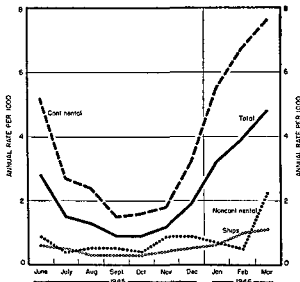


FIG 2 Morbidity Rates for Rheumatic Fever Within the U S , Afloat and at Foreign Stations (From Statistics of Navy Medicine)

attacks were most apt to occur in barracks where the morbidity rates for streptococcal nasopharyngitis were highest

3 *Association with Scarlet Fever* The incidence of rheumatic fever in the Navy during these war years was closely associated with the incidence of scarlet fever [1] The greatest incidence of scarlet fever occurred at Farragut NTC in 1943 and again late in 1944 when Re strains of types 17 and 19 became predominant. The highest incidence of rheumatic fever ever recorded in the Navy was also at Farragut In 1943 with an average strength of 43,710 there were 1,651 cases of rheumatic fever and an annual rate per 1,000 of 37.8. In 1944 with an average strength of 44,822 there

[1] 95 7% of scarlet fever cases and nearly all primary attacks of rheumatic fever occurred within continental U S.

rises in streptococcal morbidity rates occurred among personnel within the continental limits. The incidence of streptococcal throat infections among *personnel aboard ships or at non-continental stations rose only moderately*

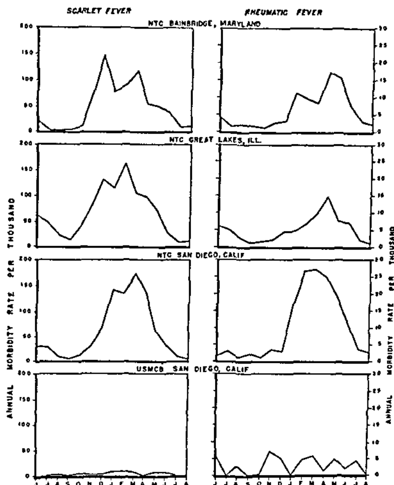


FIG 1 Seasonal Trend of Scarlet Fever and Rheumatic Fever in 1946 at Four Activities (From Statistics of Navy Medicine.)

during the winter months. This was true also for the incidence of rheumatic fever as is shown in Figure 2 and in Table 3, Chapter II.

Within the continental limits the distribution of rheumatic fever was similar to that of scarlet fever, tonsillitis and pharyngitis (16). The highest incidence of both streptococcal throat infections and also rheumatic fever

1944, at Sampson where the average strength was 41,927 there were 117 cases of rheumatic fever and a rate of 2.8. In 1945 with an average strength of 31,027 there were 518 cases of rheumatic fever and a rate of 16.7.

Other large Naval Activities having no contact with the Recruit Training Centers escaped outbreaks of scarlet fever. For example, at the Marine Corps Training Base, Parris Island, scarlet fever occurred only sporadically. The average strength was 17,719 in 1943, 15,732 in 1944 and 16,784 in 1945. The number of cases of rheumatic fever was 10 in 1943, 9 in 1944 and 10 in 1945. The morbidity rate was 0.6 in 1943, in 1944 and in 1945. The association between the low rates for scarlet fever and rheumatic fever at Parris Island and high rates for scarlet fever and rheumatic fever at Naval Training Centers is shown in Table 1.

TABLE 1

Scarlet Fever and Rheumatic Fever Rates for Selected Navy and Marine Corps Activities—1945*

Location	Average Strength	Scarlet Fever Rate	Rheumatic Fever Rate
Parris Island, S. C.	16,784	1.4	0.6
† San Diego, Calif.	92,063	27.7	4.1
Bainbridge, Md.	31,424	80.1	18.8
Sampson, N. Y.	31,027	111.2	16.7
Great Lakes, Ill.	66,466	148.6	19.2

* Computed on annual basis per 1,000 average strength

† All Navy and Marine Corps Activities in San Diego area.

The data in Table 1 show high scarlet fever and rheumatic fever rates in 1945 at the Bainbridge, Sampson and Great Lakes Training Center and low rates at the Marine Corps Training Base, Parris Island. Data for the San Diego Training Center in 1945 were not available. Both scarlet fever and rheumatic fever rates were high at the Training Center and low at the Marine Corps Base and other neighboring Naval Activities. The San Diego data in Table 1 include all Navy and Marine Corps personnel in this city. The composite rates for both scarlet fever and rheumatic fever fell into an intermediate position.

The training of Navy and Marine Corps personnel continued in 1946 at three Naval Training Centers (Bainbridge, Great Lakes and San Diego) and at two Marine Corps Training Bases (Parris Island and San Diego). The highest scarlet fever and rheumatic fever rates occurred at San Diego Naval Training Center. At Great Lakes the scarlet fever rate was high and the rheumatic fever rate moderate. Both scarlet fever and rheumatic fever rates were moderate at Bainbridge. There was little scarlet fever and

were 1,375 cases and a rate of 30.7. A large percentage of both scarlet fever infections and rheumatic fever attacks occurred at Farragut during the summer and fall months when the incidence of these two diseases was minimal at all other Naval Activities.

A close association between these two diseases was also observed at other Training Centers. For example, at Bainbridge, Great Lakes and Sampson the incidence of scarlet fever was controlled in 1944 by mass chemoprophylaxis but rose to epidemic heights in 1945 when *Re* strains became prevalent.

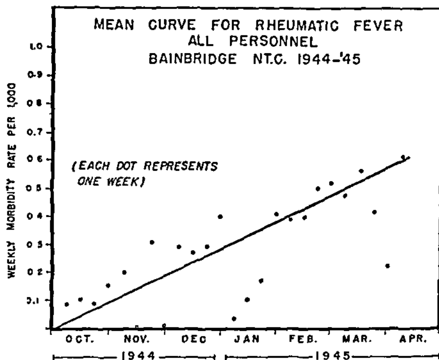


FIG 3. Seasonal Trend of Rheumatic Fever at Bainbridge N T C

In 1944, at Bainbridge where the average strength was 33,469 there were 265 cases of rheumatic fever and a rate of 7.9. In 1945 with an average strength of 31,424 there were 592 cases and a rate of 18 8. The seasonal increase in rheumatic fever, shown in Figure 3 accompanied and followed the winter epidemic of scarlet fever described in Chapter IX In 1944, at Great Lakes where the average strength was 82,788 there were 423 cases of rheumatic fever and a rate of 5.1. In 1945 with an average strength of 66,466 there were 1,277 cases of rheumatic fever and a rate of 19.2 In

The Marine Corps Base escaped outbreaks of scarlet fever and rheumatic fever.

Similar observations on the occurrence of scarlet fever and rheumatic fever were made at small Naval Activities where the average strength was less than 5,000. For example, in March 1944 there were 23 activities in which either the scarlet fever or rheumatic fever rates were at epidemic levels In 19 of these activities both the scarlet fever and rheumatic fever rates were at epidemic levels. There was only one activity which had a high rheumatic fever rate without a high incidence of streptococcal infections All personnel at this Activity had completed recruit training at Centers where streptococcal infections were prevalent There were three

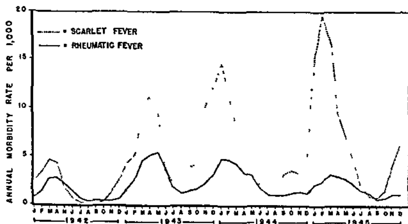


FIG 5 Seasonal Trend of Scarlet Fever and Rheumatic Fever among Navy Personne

Activities which had a high scarlet fever rate without a high rheumatic fever rate One was a training school where men were graduated in three weeks, probably prior to the onset of rheumatic fever The two remaining Activities were Midshipmen schools where young officers were trained The explanation for a low incidence of rheumatic fever in these two groups of college students is unknown

Finally, the collected statistics for the entire U. S Navy indicated that in each of the war years the trends of scarlet fever and rheumatic fever were similar, with the peak incidence of rheumatic fever following that of scarlet fever by not more than one month. The morbidity data by months are illustrated in Figure 5

In summary, these observations on more than three million personnel

rheumatic fever at the Marine Corps Training Base, San Diego. At Parris Island these two diseases occurred only rarely. These observations are illustrated in Figure 4.

At San Diego the Naval Center and the Marine Corps Base were situated

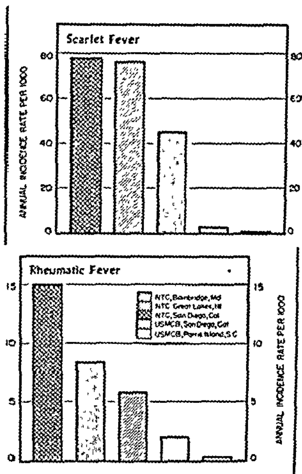


FIG 4 Rates in 1946 for Scarlet Fever and Rheumatic Fever at San Diego N.T.C. and Four Other Training Activities (From Statistics of Navy Medicine)

only a few miles apart The personnel of each Activity were similar At the Naval Training Center hemolytic streptococcus type 17 Re 25 caused a high incidence of throat infections which was followed by a high incidence of rheumatic fever. There was no contact between these two Activities.

There were 196 patients with streptococcal infections due to types 3, 6 and 12 but no patients had these organisms in the throat flora at the onset of rheumatic fever The majority of streptococcal infections appeared to be associated with type 19 The type most frequently recovered from rheumatic fever patients was type 17. These findings are shown in Table 2

Streptococcal outbreaks at several Naval Activities were caused by a single type. These outbreaks of tonsillitis and pharyngitis appeared in

TABLE 2

The Distribution of Types of Hemolytic Streptococci among Diseases and the Percent of Cases of Individual Diseases Caused by Each Type

Group		A	A	A	A	A	A	A	Not A	A	Total Each Disease
Type		19	17	1	3	6	12	?		All Other	
Catarrhal Fever	Cases	318	109	31	24	9	8	44	30	30	603
	%	52 7	18 1	5 1	4 0	1 5	1 3	7 3	5 0	5 0	100 0
Suppurative Lesions	Cases	32	34	7	4	1	0	3	4	8	93
	%	34 4	36 6	7 5	4 3	1 1	0	3 2	4 3	8 6	100 0
Pharyngitis and Tonsillitis	Cases	544	199	39	65	16	29	43	26	29	1000
	%	55 4	19 9	3 9	6 5	1 6	2 9	4 3	2 6	2 9	100 0
Scarlet Fever	Cases	342	108	5	31	0	1	11	15	8	521
	%	65 6	20 7	1 0	5 9	0	2	2 1	2 9	1 5	99 7
Rheumatic Fever	Cases	9	11	4	0	0	0	3	5	5	37
	%	24 3	29 7	10 8	0	0	0	8 1	13 5	13 5	99 9
All Other Respiratory Infections	Cases	10	13	5	2	4	2	2	11	2	51
	%	19 6	25 5	9 8	3 9	7 8	3 9	3 9	21 6	3 9	99 9
Total All Respiratory Infections	Cases	1265	475	91	126	30	40	106	91	82	2305
	%	54 9	20 6	3 9	5 5	1 3	1 7	4 6	3 9	3 6	100 0

some instances to be food-borne and in others air-borne Two outbreaks which were caused in one instance by type 1 and in another by type 12 failed to precipitate rheumatic fever In contrast to this, a severe epidemic of scarlet fever caused by type 17 Re 25 at San Diego Naval Training Center was followed by an unusually high incidence of rheumatic fever This strain caused scarlatinal rashes in at least 20% of the men infected. Follow-up observations made of a group of 500 of these scarlet fever patients, showed that 106 developed classical rheumatic fever

indicated that there was a close association in time and location between the incidence of streptococcal infections of the upper respiratory tract and the incidence of rheumatic fever. As previously reported (16) the introduction of mass chemoprophylaxis in 1944 at several Training Centers was followed by a striking reduction both in the incidence of streptococcal throat infections and in the incidence of rheumatic fever. However, in 1945 the spread of sulfonamide resistant strains of Group A hemolytic streptococcus at these Centers made chemoprophylaxis ineffective. A high incidence of scarlet fever with Re strains occurred, and this change was accompanied by a high incidence of rheumatic fever. Irrespective of the period of the war and location of personnel, rheumatic fever outbreaks occurred following epidemics of air-borne streptococcal infections of the upper respiratory tract and did not occur in their absence.

B. OBSERVATIONS ON THE HEMOLYTIC STREPTOCOCCI ASSOCIATED WITH RHEUMATIC FEVER

The collection of accurate information on the strains of hemolytic streptococci which precipitate rheumatic fever requires that throat cultures be made during acute upper respiratory tract infection which precedes the rheumatic attack Cultures made during the rheumatic attack may contain the original infecting strain or a strain subsequently acquired. During World War II, most of the bacteriologic observations on the throat flora of rheumatic fever patients in the U S Navy were made after the onset of rheumatic fever With this limitation, it was nevertheless possible to obtain information which had not been available and to confirm on a large scale observations which, prior to World War II, had been made on small numbers of civilians.

Early in World War II rheumatic fever became conspicuous at the Newport Naval Training Station following an epidemic of scarlet fever. *Hemolytic streptococcus type 6 was the important agent at this Station.* Later, an outbreak of rheumatic fever occurred at a small Coast Guard Activity in Maryland (29) The important bacterial agents appeared to be *hemolytic streptococcus types 14 and 3* The scarlet fever epidemics at most of the stations in 1944 and 1945 were caused by several types of organisms It appeared that some strains of types 19 and 17 were the most "rheumatogenic" agents. At Farragut, Idaho, an analysis was made in 1944 to determine the percentage of cases of individual diseases associated with each type of hemolytic streptococcus This analysis included 2305 patients whose throat strain of hemolytic streptococcus was typed serologically Types 19 and 17 were associated with 71% of cases diagnosed as "catarrhal fever," with 71% of suppurative lesions, with 75% of tonsillitis and pharyngitis, with 80% of scarlet fever and with 54% of rheumatic fever.

CHAPTER XIX

METHODS EMPLOYED IN THIS FOUR YEAR NATIONWIDE STUDY OF STREPTOCOCCUS HEMOLYTICUS

The impact of a global war emphasized the necessity for training teams of U S Navy men to do special field work on the problems of exotic and epidemic diseases To this end, the Navy established a new department in its Medical Center at Bethesda, Maryland, where medical officers, Hospital Corps officers and enlisted men were assigned to duty for instruction in epidemiology The first class began its training October 1, 1942, and the last class was graduated December 1, 1945 During these three years 130 officers and 397 enlisted men received intensive training in epidemiology Most of these specially trained personnel were assigned to Epidemiology Units operating within and without the continental limits of the United States Their location was shifted as demands were made by the progress of the war

Twenty-one of these Epidemiology Units were established within the continental limits of the United States All but one conducted field studies, sanitation work and laboratory examinations in accordance with the needs of the Naval Activity to which the Unit was attached The size of Units varied from two officers and three enlisted men to six officers and twelve enlisted men The larger Units were located at the Training Centers where streptococcal diseases presented the greatest problem One Unit was established at the Navy Medical School in Bethesda, Maryland, for the purpose of integrating all of the streptococcal laboratory work of the Navy This Unit examined all cultures of hemolytic streptococcus shipped in from distant Activities, trained its personnel in highly specialized techniques and developed new methods required for handling streptococcal problems of the Navy The geographical locations of these 22 Epidemiology Units is shown in Chapter I, Figure 1.

All of the grouping, typing and sulfonamide resistance tests were done in [illegible] h Unit grouped its cultures and [illegible] A study at the Great Lakes [illegible] hs of 1945 required that these tests be made with a minimal loss of time. To achieve this technicians from the Bethesda laboratory were transferred to Great Lakes where they used the Bethesda materials and techniques. Their results were checked from time to time in Bethesda.

SUMMARY

Outbreaks of rheumatic fever were observed in only those locations and times that epidemics of streptococcal infections occurred.

Rheumatic fever was most prevalent in the Northern states but also, in one instance, reached a high incidence in the warm, sunny climate of San Diego, California. This high incidence was associated with a scarlet fever epidemic caused by a single strain of Group A type 17 Rc 25 hemolytic streptococcus.

Throughout the Navy in World War II the strains of hemolytic streptococcus which showed capacity to induce rheumatic fever in high incidence were those which also produced scarlet fever in high incidence.

It appeared that probably the most significant factor in the initiation of rheumatic fever among an average population is a "rheumatogenic" substance produced by some strains of Group A hemolytic streptococcus.

Only a small fraction of Navy recruits infected with these streptococcal strains while living under the same environmental conditions developed rheumatic attacks The reason for this difference in reactivity of the host to infection was not determined.[1] This remains the key problem in the pathogenesis of rheumatic fever.

[1] This matter is dealt with by one of the authors (A. F. C) in Research in Medical Science, MacMillan Company, in press.

the tube, flamed and pushed into the tube until the burning was extinguished and the cotton plug flush with the top of the tube. While still warm, the open end of the tube was sealed with a wrapping of parafilm or paraffin.

4 *Shipping Specimens*· An identification slip was made out for each culture and securely fastened to the tube with a rubber band. The tests desired were indicated on the slip. Each culture was given a station number and later a number at Bethesda If a rapid report was desired this was indicated on the slip and the culture was given top priority at Bethesda. Prior to mailing, the slants of cultures were kept at 4°C. When appropriate numbers of slants had been collected they were carefully packed and shipped in mailing containers by air mail In most instances cultures were shipped to Bethesda, Maryland as soon as practicable after identification and isolation

B. LABORATORY METHODS USED BY EPIDEMIOLOGY UNIT #100 AT U. S NAVAL HOSPITAL, BETHESDA

Some of the methods employed in the Bethesda Laboratory have been described by Armine T Wilson (4, 16)

1 *Grouping of Hemolytic Streptococcus* Group A beta hemolytic streptococci are responsible for almost all hemolytic streptococcal respiratory illnesses in man. For this reason, work was restricted chiefly to this group On the basis of presence or absence of a precipitin reaction with a potent and specific absorbed Group A serum, it was possible to determine whether a strain belonged in Group A Strains that were not members of Group A were not further identified except in special studies

2 *The Basis of Typing Hemolytic Streptococcus* There were two methods of typing Group A streptococci in current use. the slide agglutination method and the precipitin technique as modified for use in capillary tubes. From an epidemiologic point of view, it mattered little which method was used to determine the type of a strain so long as the same method was used for all the material to be treated in one analysis. However, the results of the two methods are not always in agreement because in certain instances they measure different antigenic components of the organism For this reason, all typing work was done by one technique, the precipitin method

Hemolytic streptococci of Group A have two type-specific antigens, known as M and T. In precipitin typing, only the M antigen of M substance is involved The M antigen is protein in nature and is extractable from the cell into solution by acid. When such a cell-free extract is neutralized and placed in contact with an anti-M containing serum prepared from a strain of the same type, a precipitin reaction occurs With serums

A. METHODS USED BY EPIDEMIOLOGY UNITS IN FIELD WORK

Each Unit was attached to the Senior Medical Officer of a Naval Activity. The work of each Unit and the methods employed varied from station to station. In general, the objectives were to define more clearly the local streptococcal problem and recommend ways for its solution. Members of the Units kept clinical records on patients with streptococcal infections, checked the diagnoses, made monthly reports of their observations, conducted controlled programs for testing chemoprophylaxis and other preventive measures, obtained appropriate cultures, did the preliminary bacteriologic study prior to the shipment of cultures to Bethesda, initiated investigations and made analyses of their findings. The collecting and handling of data varied with the size of the station and the ideas of medical officers. However, the bacteriologic study was done uniformly.

1. *Preparation of Media*: A simple, adequate medium was made in uniform manner by all Units The agar base used was Difco Bacto Blood Agar Dehydrated prepared according to Difco Instructions Either defibrinated rabbit blood or defibrinated horse blood was added. The agar base was kept sterile in 250 cc lots, melted and cooled to the appropriate temperature To this was added 7.5 cc of sterile blood. After thorough mixing the blood agar was poured in sterile Petri dishes to a depth of about 3 mm The plates were either used within a few hours or stored in an icebox at 5°C until needed

2 *Collecting Specimens* Throat and nose cultures were taken with sterile swabs made with a small amount of cotton compressed tightly on the end of an applicator stick In taking throat cultures the tip of the swab was pressed firmly against the lymphoid tissue or the inflamed area at the site of exudate if present The swab was then streaked on blood agar plates at the bedside if possible. Where this was not possible swabs were kept moist in tubes of broth and streaked in the laboratory. The periphery of the blood agar plate was inoculated with the tip of the swab and then streaked with a sterile platinum loop to insure a good field of isolated colonies on the plate After 18 to 24 hours' incubation the plates were examined and hemolytic colonies picked. Appropriate Gram stain and microscopic examinations were made to make sure that the colonies picked were Gram positive and streptococci.

3 *Handling Specimens* When the organism was identified as Beta hemolytic streptococcus and in pure culture, a sub-culture was made on a blood agar slant in a small tube. This was incubated for 18 to 24 hours and then inspected for absence of contamination and adequacy of growth. If the slant was satisfactory, the cotton plug was cut about one inch above

the tube, flamed and pushed into the tube until the burning was extinguished and the cotton plug flush with the top of the tube. While still warm, the open end of the tube was sealed with a wrapping of parafilm or paraffin

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1. *Grouping of Hemolytic Streptococcus* Group A beta hemolytic streptococci are responsible for almost all hemolytic streptococcal respiratory illnesses in man For this reason, work was restricted chiefly to this group. On the basis of presence or absence of a precipitin reaction with a potent and specific absorbed Group A serum, it was possible to determine whether a strain belonged in Group A. Strains that were not members of Group A were not further identified except in special studies.

2 *The Basis of Typing Hemolytic Streptococcus*· There were two methods of typing Group A streptococci in current use: the slide agglutination method and the precipitin technique as modified for use in capillary tubes. From an epidemiologic point of view, it mattered little which method was used to determine the type of a strain so long as the same method was used for all the material to be treated in one analysis However, the results of the two methods are not always in agreement because in certain instances they measure different antigenic components of the organism. For this reason, all typing work was done by one technique, the precipitin method.

Hemolytic streptococci of Group A have two type-specific antigens, known as M and T In precipitin typing, only the M antigen of M substance is involved. The M antigen is protein in nature and is extractable from the cell into solution by acid When such a cell-free extract is neutralized and placed in contact with an anti-M containing serum prepared from a strain of the same type, a precipitin reaction occurs. With serums

prepared from other types, no such reaction occurs, provided the serums have had their group and non-type-specific antibodies removed by absorption.

The method of precipitin typing consists of placing an acid extract of an unknown strain in contact with the absorbed anti-M serums of all known types. The type with which the extract reacts is the type of the strain.

In the intact cell the M substance usually, although not always, participates in an agglutination reaction when a suspension of cells is added to an anti-M containing serum of the same type. The antibodies to the M substance also appear to be responsible for whatever type-specific immunity an animal acquires when actively or passively immunized.

The T antigen, on the other hand, has not yet been identified chemically nor can it be demonstrated outside of the cell. Its presence is recognized only by agglutination of the intact cell in the corresponding anti-T serum. So far as is known, it is not involved in a precipitin reaction, and it does not appear to influence the immunity of the animal to infection.

Whereas the precipitin typing method depends entirely on the reaction of the M substance of the organism with its corresponding antibodies, the slide agglutination typing method may involve the M substance and its antibody, or the T antigen and its antibody, or both. If particular M and T antigens were invariably associated in particular types, there would be no reason for confusion in the use of the two tests. However, this is not the case (30). Some strains are without demonstrable M substance, although they contain T antigen, and other strains are without T antigen, although they contain M substance. Some strains, which share the same M substance and hence will be assigned to the same type on the basis of precipitin typing, have T antigens of different types and are accordingly assigned to different types when tested by slide agglutination. Other strains with the same or serologically related T antigens have distinct M antigens. One strain has been encountered with the M antigen of one type, a T antigen of the same type and an additional T antigen of another type

A complete antigenic analysis requires that both precipitin and agglutination techniques be employed with serums of accurately known antigenic composition. *The unusual combinations of antigens mentioned, though* not frequent, occur often enough to make it unsafe to compare epidemiologic data based on slide agglutination typing alone with data based on precipitin typing alone. For most epidemiologic purposes a single method usually suffices. The choice of method to be used in any given investigation depends on the availability of reliable serums and the experience of the persons doing the typing

3. *Method of Typing Hemolytic Streptococcus* The capillary precipitin

method of Swift, Wilson and Lancefield (2) was used exclusively throughout this study. The details of that method were given in full in their article, and are reviewed only briefly here The method was devised in an attempt to make precipitin typing practicable in large scale typing enterprises, and the essential advantage which it possesses over commonly used precipitin tests lies in the conservation of materials made possible by the use of capillary tubes The serums used in capillary typing must be of high potency and specificity. Ample supplies of such serums were made available through the generosity of Doctors Homer F. Swift and Rebecca C Lancefield of the Hospital of the Rockefeller Institute for Medical Research.

Precipitin testing in capillaries is accomplished by drawing a small amount of serum into the capillary tube by capillary attraction, and then drawing an approximately equal amount of extract into the tube without allowing an air bubble to separate the two liquids Depending on the strength of the serums used, the precipitate appears immediately, or after 2 hours' incubation at 37°C., or after having been kept overnight in the icebox.

Strains were sent from the field to the Bethesda laboratory as soon as possible after isolation They were stored at 5°C until ready for study. They were then tested for pure culture and were grown in 40 cc of tryptose phosphate broth, fortified with 0 15 percent normal horse serum or rabbit serum The organisms obtained from such cultures were extracted with hydrochloric acid. After the extract was neutralized, it was ready for grouping and typing, the same extract was used for the two procedures

Early observations showed that most of the Navy strains which were examined fell into ten common types: 1, 3, 5, 6, 12, 17, 18, 19, 24 and 30 For this reason it was decided to set up the extracts first with these ten serums If the strain did not belong to one of these types then common in the Navy, it was set up with the other typing serums These screening procedures resulted in a significant saving of time, serums and capillaries

Serums were available for 36 of the 46 known types of Group A beta hemolytic streptococci In addition to the ten common ones listed, these were 2, 4, 8, 9, 11, 13, 14, 15, 22, 23, 26, 28, 29, 31, 32, 33, 36, 37, 38, 39, 40, 41, 42, 43, 44 and 46

4. *A Method for Testing in Vitro Resistance of Group A Hemolytic Streptococci to Sulfonamides* Most culture media which support the growth of Group A hemolytic streptococci contain substances antagonistic to the action of sulfonamides. For this reason it had not been possible to detect with accuracy the intrinsic differences in sensitivity of streptococcal strains to sulfonamides

The capacity of streptococcal cells to multiply in vitro in the presence of sulfonamides is determined not only by inherent differences in sensitivity

to this drug but also by the character of the medium and the size of the inoculum. A medium which is to be used for testing sulfonamide sensitivity of a microorganism should meet certain requirements: it should be essentially free of substances antagonistic to sulfonamide action and it should make provision for a uniform and measurable inoculum.

The semi-synthetic medium used in this test was developed by Adams and Roe (3) for the growth of pneumococci. This medium was found to support adequate growth of hemolytic streptococci when supplemented with normal rabbit serum or with normal horse serum and xanthine. The inoculation technique employed in this test was adopted from the technique of Ward and Rudd (31). It was used by them to differentiate growth characteristics of streptococcal colonies in a semi-solid medium. The medium used at Bethesda for testing sulfonamide sensitivity was prepared as follows:

Preparation of Stock Solutions: Solution I: (Basal Medium) Caseine hydrolysate (10% solution, SMACO "vitamine free") 200 cc, Cystine 150 mg, Tryptophane 20 mg, KCl 3.0 gm, Na_2HPO_4 (anhydrous) 3.0 gm, and $MgSO_4 \cdot 7H_2O$, 0.5 gm. The cystine was dissolved in 10 cc N HCl. The ingredients were mixed in about 800 cc. of distilled water. The pH was adjusted to 7.5, and the volume was made up to 900 cc. The final mixture was autoclaved at 10 lbs. for 10 minutes, filtered through paper, and re-autoclaved for sterility.

Solution II (Vitamins) Biotin 0.015 mg, Nicotinic acid 15.0 mg, pyridoxin 15.0 mg, calcium pantothenate 60.0 mg, thiamine chloride 15.0 mg, riboflavine 7.0 mg., adenine sulfate 150.0 mg, and uracil 150.0 mg. The ingredients were dissolved in about 75 cc of distilled water and the pH adjusted to 7.2, the volume made up to 100 cc with distilled water and the final solution sterilized by filtration.

Solution III. (Minerals) $CuSO_4 \cdot 5H_2O$ 50.0 mg, $ZnSO_4 \cdot 7H_2O$ 50.0 mg, $FeSO_4 \cdot 7H_2O$ 50.0 mg, $MnCl_2 \cdot 4H_2O$ 20.0 mg, and concentrated HCl 1.0 cc, distilled water to 100.0 cc. This solution did not require sterilization.

Solution IV (Growth factors) Glutamine (kept in dessicator over calcium chloride at 4°C.) 200.0 mg, dextrose 2.0 gm, Solution III 2.0 cc, $CaCl_2 \cdot 2H_2O$ 10.0 mg, asparagine 100.0 mg, Choline chloride 10.0 mg, and distilled water 40.0 cc. This was sterilized by filtration.

Solution V (Growth factors, Vitamins and Minerals) Solution IV 12.0 cc. and Solution II 8.0 cc.

Solution VI R $NaHCO_3$ (sterilized by autoclaving in dry test tubes) 0.2 gm, distilled water (sterile) 10.0 *cc*, and thioglycollic acid (*10% solution, sterilized by* boiling) 0.2 cc. This solution was used when the medium was made with rabbit serum.

Solution VI H $NaHCO_3$ (prepared as in solution VI R) 0.2 gm, sterile distilled water 8.0 cc, sterile 10% thioglycollic acid 0.2 cc, and xanthine solution (100 mg xanthine per 100 cc N/20 NaOH) sterilized by filtration 2.0 cc. This solution was used when the medium was made with horse serum.

It was then filtered through absorbent cotton until clear, distributed in convenient amounts and autoclaved

Stock sodium sulfadiazine solutions containing 0 1 gm , 1 0 gm , and 5 0 gm of drug per 100 cc distilled water were sterilized by immersion in a boiling water bath for 10 minutes

With the exception of Solutions VI R and VI H, which had to be prepared immediately before use, all of the above solutions were made in advance and stored in the ice box until needed

Technique of Testing To perform the test the various solutions were mixed in five sterile Erlenmeyer flasks of suitable size The quantities used for 24 tests are shown in Table 1 Fractions or multiples of these quantities were used in accordance with the number of strains to be tested Solutions I, V, VI R and rabbit serum or VI H and horse serum, saline and sodium sulfadiazine were added to the flasks which were

TABLE 1

Dilution Schedule for 24 Tests

	Control	1 mg	5 mg	25 mg	125 mg
Solution I (Basal Medium)	33 0	33 0	33 0	33 0	33 0
Solution V (Growth Factors, Vitamins and Minerals)	2 5	2 5	2 5	2 5	2 5
Solution VI R or VI H	2 5	2 5	2 5	2 5	2 5
Serum	5 0	5 0	5 0	5 0	5 0
Saline (0 85% NaCl)	2 0	1 5	1 75	1 75	0 75
SSD* 0 1%	—	0 5	—	—	—
SSD* 1 0%	—	—	0 25	0 25	—
SSD* 5 0%	—	—	—	—	1 25
Solution VII	5 0	5 0	5 0	5 0	5 0

* SSD—Sodium sulfadiazine solutions

All measurements are in cc

then placed in a 48°C water bath Solution VII was melted in the autoclave and placed in the water bath When all solutions reached the same temperature, the indicated quantity of Solution VII was added to each flask by means of warmed pipettes and the final solutions were then distributed in 2 0 cc amounts in sterile 13 x 100 mm test tubes Thus 5 tubes constituted the test materials for a single strain and contained respectively concentrations of 0, 1, 5, 25 and 125 mg of sodium sulfadiazine per 100 cc of the medium

Strains to be tested were grown overnight in 2 0 cc of a medium composed of Solution I, 80%, Solution V, 5%, and when rabbit serum was used 10% of the serum and 5% Solution VI R, or when horse serum was used 10% of that serum and 5% Solution VI H

A small loopful (the loop is made by winding 26 gauge platinum wire around an 18 gauge needle) of this culture was transferred to 2 0 cc of Solution I in a test tube This dilute cell suspension was agitated sharply 30 times, and a loopful of it transferred to each of the 5 tubes constituting the test The loop was flamed between inoculations The inoculum was considered to be of satisfactory size if 10 to 100

colonies grew in the tube which contained no sulfonamide. If the number of colonies was not within these limits the test had to be repeated with a suitable inoculum.

The tubes were incubated at 37°C. for 18 to 24 hours and the test was read in terms of the concentration of sodium sulfadiazine in the highest tube in which visible growth occurred. Thus if there was growth in the control tube only, the result was "0" If growth occurred in all tubes except that containing 125 mg of the drug per 100 cc. of medium the result was "25."

Discussion: Experience with this method showed that results were reproducible with a variation of plus or minus one tube. Strains could be kept on blood agar slants in the ice box for periods up to one month without undergoing a change in in vitro resistance.

Obtaining consistent results required that the same sulfonamide and serum from the same species be used. It was found, for instance, that sodium sulfathiazole gives readings about one tube lower than sodium sulfadiazine, and that the medium made with rabbit serum gives readings about one tube higher than that made with horse serum and xanthine.

The semi-synthetic part of the medium was without doubt unnecessarily complex, because a number of its constitutents were contributed in sufficient quantity by the added serum. No attempt was made, however, to eliminate these superfluous materials or to reduce the medium to its simplest form.

Many strains of hemolytic streptococci were inhibited by as little as 0.2 mg of sodium sulfadiazine per 100 cc of the medium, indicating that the content of substances antagonistic to sulfonamide action was low.

Attempts to refine the test for demonstrating lesser degrees of sulfonamide resistance were unsuccessful The intervals between the concentrations of drug in the tubes (multiples of 5) were chosen deliberately and the good correlation which was found to exist between the findings of the test and clinical observations in the field indicated that the test was sufficiently precise to be of practical value.

C METHODS USED FOR OILING

1 *Blankets* The blankets were oiled in the standard commercial laundry equipment

First, the wheels of each rotator were streamed and thoroughly washed to remove adhering soap

Twelve inches of water, temperature 80–85°F., were introduced

Twenty blankets were unfolded and placed in each compartment of the rotator

After 10–15 revolutions of the rotator, 1450 cc. of oil (supplied by the Standard Oil Company of California) were introduced on the "down beat" of the rotator through each of the outer openings.

Agitation was continued slowly. Then 500 cc. of 40% Roccal, diluted 1 to 4 in tap water, were added to each compartment

The original turbidity of the emulsion became nearly water clear This occurred in 5 to 10 minutes.

This procedure was followed in oiling the white blankets of the Navy. For olive drab blankets the quantity of Roccal was reduced from 500 cc. to 150 cc

2 *Floors* The floors were cleaned and oiled according to the methods to be described in Chapter XVII, p 165 (32).

D. METHODS USED FOR COLLECTING SAMPLES OF BACTERIA FROM BLANKETS, BED CLOTHING AND PERSONAL BELONGINGS

The principal limiting factors in making dust culture surveys were the time necessary to collect samples in an aseptic manner and their processing in the laboratory

At first samples of dust from bedding, including blankets, sheets, mattress cover and mattress were collected by shaking the article being tested over one or more blood agar plates which had previously been opened and placed on the deck After each specimen was obtained it was necessary to swab the deck and allow the room to air a sufficient time to prevent contamination of the succeeding culture by air-borne and dust-borne organisms disseminated by previous sampling The only alternative to this lengthy procedure was to use a different room in obtaining each sample This was not practical, therefore it was necessary to devise a simpler method.

A method was developed and found practicable for these studies

First, a Petri dish containing 5% blood agar was opened. The half containing the medium was held firmly in the fingers, inverted and brought gently several times to the surface of the article being tested. The cover was then replaced and the plate placed in the incubator.

The advantages of this method were:

(1) A known area of bedding could be sampled or the entire surface could be covered; (2) it was not necessary to remove the article being tested from the bed to obtain the sample, (3) the extra work entailed in swabbing the floor and airing the room was eliminated, (4) the danger of cross contamination, inherent in the method formerly used, was removed, (5) sampling was much simpler and each specimen required only a fraction of the time used in obtaining cultures by the former method

E. METHODS USED FOR COLLECTING DUST SAMPLES

At first samples of floor dust were collected by covering a brush with a strip of flannel and sweeping the dust on a sheet of sterile paper. This was transferred to an envelope. One gram of dust was weighed and mixed in

100 cc. of sterile physiologic salt solution. Blood agar pour plates were made at once with several measured quantities of the suspension.

Later the floor dust was sampled in a manner similar to that used for bedding. A two inch wide strip of stockinet was placed on the lower part of the Petri dish containing the culture medium The Petri dish cover was fitted over the stockinet. The dish was then autoclaved, the cover lifted and the sterile blood agar poured in and allowed to harden. Samples of dust were collected by tapping the open, inverted medium-containing and stockinet-covered lower part of the Petri dish on the floor. A few gentle taps were found sufficient to give a satisfactory sample. After collecting the sample, the stockinet was removed from the Petri dish, autoclaved and reused.

The advantages of this method were that it saved time and permitted taking samples from many points in a single room. The only disadvantage was its not being quantitative.

CHAPTER XX

OBSERVATIONS ON THE RELIABILITY OF TESTING STREPTOCOCCUS HEMOLYTICUS FOR SEROLOGIC TYPE AND SULFONAMIDE RESISTANCE

The serologic type and sulfonamide resistance of certain strains of hemolytic streptococcus appeared to be fixed characteristics by which organisms might be identified Testing for these two characteristics was done in each instance from a [illegible] grown from a single colony picked at [illegible] not known [illegible] bacterium could be determined from the selection of a single colony Furthermore, information was lacking on whether organisms which grew in vitro in the presence of sulfonamide were resistant clinically to sulfonamide. The following studies were made to determine the usefulness of serologic typing and the testing of sulfonamide resistance in epidemiologic work.

A THE RELIABILITY OF DETERMINING THE SEROLOGIC TYPE BY FISHING A SINGLE COLONY FROM A BLOOD AGAR PLATE

Satisfactory sera were available at Bethesda for classifying 36 types of Group A hemolytic streptococcus A large majority of the organisms shipped to Bethesda proved to be one of the three common types All of these organisms were throat strains The persons cultured either had acute infections of the naso-pharynx or were potential carriers of hemolytic streptococcus At each station appropriate numbers of cultures were taken to supply information on the prevailing types and causative agents in epidemic outbreaks However, the culture examined at Bethesda were grown from one colony of a blood agar plate which in most instances had been covered with hundreds of colonies swabbed from the subject's pharynx

The reliability of testing the serologic type causing an acute streptococcal throat infection by picking a single colony was determined by Lt Commander Douglas Damrosch. Seventy-eight patients with scarlet fever, tonsillitis or pharyngitis at seven Naval Activities were selected In each instance a cotton swab was pressed firmly against the inflamed area of the pharynx and then immersed in a tube of broth culture The tubes were taken directly to the laboratory. A wire loopful of the inoculated broth was placed in a sterile Petri dish and melted blood agar at the appropriate temperature poured on this medium The plate was incubated for

24 hours at 37 degrees C. Ten surface colonies of hemolytic streptococcus were picked, handled in the routine manner and shipped to Bethesda.

Another group of 50 patients with streptococcal throat infections at the same seven Naval Activities were selected for a second study. Two cultures were made from the throats of these patients. The cultures were handled in the same manner. Twenty colonies were then picked and so labeled as to prevent any association being recognized in the laboratory at Bethesda.

The results were consistent. In the first collection of 78 groups of cultures a single type was obtained from 62 (82%). The probability of obtaining the correct type from a single colony as determined by testing these 780 cultures was 94%. In the second collection of 50 groups of cultures a single type was obtained from 46 (92%). The probability of obtaining the correct type from a single colony as determined by testing these 1,000 [illegible] a single colony was between 94% and 99% in the laboratory.

B. THE RELIABILITY OF DETERMINING THE SULFONAMIDE RESISTANCE BY FISHING A SINGLE COLONY FROM A BLOOD AGAR PLATE

A large percentage of the cultures of hemolytic streptococcus typed in the twelve months, September, 1944 to September, 1945, were tested for sulfonamide resistance With the exception of a few cultures of type 6 from Bainbridge, sulfonamide resistant (Re) strains were limited to types 19, 17 and 3 These three types caused a majority of the streptococcal diseases in the Navy during the war years. During the final year of the war a number of streptococcal outbreaks were initiated by strains which were not only of a single type but which also showed uniform resistance in vitro to one concentration of sulfadiazine These organisms were resistant, as tested by Wilson's method,[1] to all of the sulfonamides[2] in therapeutic use. They were tested only against arbitrarily selected dilutions of sulfadiazine in five tubes containing 0, 1 mg %, 5 mg. %, 25 mg. %, and 125 mg. % *The reliability of judging the sulfonamide resistance by picking* a single colony was determined on the same cultures used for investigating the accuracy of typing There were 780 cultures from 78 patients in one shipment and 1,000 cultures from 50 patients in the second shipment. Thirty-three of the 78 patients and 23 of the 50 patients had organisms of types other than 19, 17 and 3.

[1] Later in this study 43 strains were tested by the method of Harper and Cawston (33). Similar results were obtained for only 29 of these organisms

[2] The sulfonamide resistant organisms (Re strains) were not resistant in vitro to "Marfanil" or to British drugs, V147, V187 and V335

Theoretically, all of the organisms should have been sulfonamide sensitive However, there were three exceptions in the ten-colony study and two exceptions in the twenty-colony study. The probability of detecting sulfonamide sensitivity in vitro from a single colony as determined by testing ten colonies was 99% and as determined by testing 20 colonies was 91%. These organisms were Group A hemolytic streptococcus of types other than 19, 17 and 3.

About half of these patients selected at random at seven Naval Activities were infected with types 19, 17 and 3. In the first series 35 of 78 and in the second series 27 of 50 were of these types Some of these cultures were sulfonamide sensitive; others were sulfonamide resistant in vitro to different degrees Data on the sensitivity to sulfadiazine of the type 19, 17 and 3 organisms are given in Table 1.

This table shows that in addition to the sensitive organisms there were several classes of resistant strains. type 19 Re 25; type 17 Re 5, Re 25 and Re 125; type 3 Re 5 With a single exception no culture varied in resistance by more than one tube, even though the tests were done at different times and by several persons Under these conditions the probability of correct classification of a single colony of type 19, 17 or 3 ranged from 80 to 99%

Accepting the probability of correct classification from a single colony of types 19, 17 and 3 as 80%, one has a probability of at least 72% in identifying the causative agent of an epidemic in which 90% or more of cultures are of one type with uniform sulfonamide resistance.

C A COMPARISON OF IN VITRO AND IN VIVO SENSITIVITY OF STREPTOCOCCAL STRAINS TO SULFADIAZINE

The determinations on sulfonamide resistance showed only the capacity of certain organisms to grow in one medium when sulfonamide was present It seemed probable that these organisms were also sulfonamide resistant in vivo. However, controlled studies on the effectiveness of sulfonamides administered daily to groups in which resistant strains were present, were required to establish this point

1 *Procedure* Sulfadiazine, one gram daily, was administered at several Activities in November and December, 1944 The investigation of the effectiveness of prophylaxis was controlled as follows:

(a) At certain stations, alternate men received sulfadiazine and their barrack mates served as controls, (b) at other stations all men in alternate barracks within a regimental area received sulfadiazine and the remainder served as controls, (c) at one station prophylaxis was administered to all men in a recruit regiment during an epidemic of scarlet fever. The following observations were made in these groups:

TABLE 1

Observations on the Accuracy of Determining the Sulfonamide Resistance of Hemolytic Streptococcus

Classification of Strains	Serologic Type of Hemolytic Streptococcus	Number of Colonies Picked	Percentage Showing Resistance to Sulfadiazine, mg %					Probability of Classifying Resistance from a Single Colony
			0	1	5	25	125	
Type 19	19	10	100					
	19	10	100					
	19	10	100					
	19	10	100					
	19	10	100					
	19	20	100					99%
	19	20	100					
	19	20	100					
	19	20	100					
	19	20	100					
	19	20	95	5				
	19	20	95	5				
	19	20	95	5				
Type 19 Re 25	19	10			60	40		
	19	10			10	90		
	19	10			10	90		
	19	10			10	90		
	19	10				100		
	19	10				100		
	19	10				100		89%
	19	10				100		
	19	10				100		
	19	10				90	10	
	19	20	5		5	90		
	19	20			10	90		
	19	20			15	85		
Type 17	17	10	80	20				80%
	17	10	80	20				
Type 17 Re 1	17	10		70	30			—
Type 17 Re 5	17	10			100			
	17	10			100			
	17	20			85	15		80%
	17	20			60	40		
	17	20			55	45		

Classification of Strains	Serologic Type of Hemolytic Streptococcus	Number of Colonies Picked	Percentage Showing Resistance to Sulfadiazine, mg. %					Probability of Classifying Resistance from a Single Colony
			0	1	5	25	125	
Type 17 Re 25	17	10				100		
	17	10				100		
	17	10				100		
	17	10				100		90%
	17	10				100		
	17	10				70	30	
	17	20			25	75		
	17	20			5	95		
	17	20			5	95		
	17	20			20	80		
	17	20			20	80		
	17	20			15	85		
Type 17 Re 125	17	10				10	90	
	17	10					100	96%
	17	10					100	
Type 3	3	10	100					
	3	10	100					
	3	10	100					
	3	10	100					
	3	20	100					
	3	20	100					99%
	3	20	100					
	3	20	100					
	3	20	100					
	3	20	95	5				
	3	20	95	5				
Type 3 Re 5	3	10		90	10			90%
	3	10		90	10			

(a) *Chemoprophylaxis administered to alternate men* Activity M_1 had a complement of approximately 1100 trainees between November 1 and November 20 These men were barracked in one building Between November 7 and 20 there were no Group A streptococcal infections in half of these men receiving prophylaxis There were ten Group A streptococcal infections in the controls The causative agents were types 19, 17 and 3 Chemoprophylaxis was 100% effective and 100% of the streptococcal strains tested were sensitive to sulfadiazine.

Activity M_1 received new trainees during the last week of November Between November 28 and December 20, when this class was graduated,

TABLE 1

Observations on the Accuracy of Determining the Sulfonamide Resistance of Hemolytic Streptococcus

Classification of Strains	Serologic Type of Hemolytic Streptococcus	Number of Colonies Picked	Percentage Showing Resistance to Sulfadiazine, mg %					Probability of Classifying Resistance from a Single Colony
			0	1	5	25	125	
Type 19	19	10	100					
	19	10	100					
	19	10	100					
	19	10	100					
	19	10	100					
	19	20	100					99%
	19	20	100					
	19	20	100					
	19	20	100					
	19	20	100					
	19	20	95	5				
	19	20	95	5				
	19	20	95	5				
Type 19 Re 25	19	10			60	40		
	19	10			10	90		
	19	10			10	90		
	19	10			10	90		
	19	10				100		
	19	10				100		
	19	10				100		89%
	19	10				100		
	19	10				100		
	19	10				90	10	
	19	20	5		5	90		
	19	20			10	90		
	19	20			15	85		
Type 17	17	10	80	20				80%
	17	10	80	20				
Type 17 Re 1	17	10		70	30			—
Type 17 Re 5	17	10			100			
	17	10			100			
	17	20			85	15		90%
	17	20			60	40		
	17	20			55	45		

prophylaxis was 100% effective, and the strains tested were 100% sensitive to sulfadiazine.

Activity G had a complement of approximately 4200 trainees during November and December. Living arrangements and sulfadiazine administration were similar to those of Activities E and F. During the two month period there were two Group A streptococcal infections among the men receiving prophylaxis and thirty-seven (types 12, 3, 30, 37 and 18) in the control group. Chemoprophylaxis was 95% effective and 100% of the strains tested were sensitive to sulfadiazine.

Activities L, M, N and O were comparable to activities E, F and G. The barracking and sulfadiazine administration were also similar to these three activities

Activity L had a complement of approximately 1,600 men Between November 8 and December 31, there were thirteen Group A infections (type 17) among the men receiving prophylaxis and eighty-two (types 19, 3, 6, 12, and 17) in the control group Chemoprophylaxis was 84% effective and 88% of the strains tested were sensitive to sulfadiazine.

Activity M had a complement of approximately 4,500 men Between November 8 and December 31, there were twenty-two Group A streptococcal infections (type 17) among the men receiving prophylaxis and one hundred ninety-seven (types 6, 19, 44, 17, 12 and 3) in the control group. Chemoprophylaxis was 89% effective and 86% of the strains tested were sensitive to sulfadiazine

Activity N had a complement of approximately 5,000 men Between November 8 and December 31, there were twenty-one Group A streptococcal infections (type 17) among the men receiving prophylaxis and three hundred seventy-four in the control group (types 6, 19, 44, 3 and 17). Chemoprophylaxis was 95% effective and 90% of the strains tested were sensitive to sulfadiazine.

Activity O had a complement of approximately 4,000 men. Between November 8 and December 31, there were seventeen Group A streptococcal infections (type 17) among the men receiving prophylaxis and two hundred twenty-four (types 6, 19, 44, 3 and 17) in the control group. Chemoprophylaxis was 92% effective and 100% of the strains tested were sensitive to sulfadiazine

Activity P had a complement of approximately 3,000 men. Between September 18 and October 8, there were eighty-eight Group A streptococcal infections (types 19 and 17) among the men receiving prophylaxis and seventy (types 19 and 17) in the control group. Chemoprophylaxis was ineffective. In fact, the morbidity rate among the group receiving sulfadiazine was higher than among the controls and 12% of the strains tested were susceptible to sulfadiazine.

(c) *Chemoprophylaxis administered to all men in a recruit regiment* An

there were 17 Group A streptococcal infections (types 3 and 17) among the men receiving prophylaxis and 51 Group A infections (types 3, 30, 6, 19, 17 and 1) among the controls. Chemoprophylaxis was 65% effective and 76% of the strains tested were sensitive to sulfadiazine.

Activity W_1 had a complement of approximately 900 trainees between November 7 and December 4, 1944. These men were barracked in one building. Between November 14 and December 4 there were five Group A streptococcal infections (types 17 and 3) among the men receiving prophylaxis and thirty-nine (types 19, 17, 3, 1 and 44) in the control group. Chemoprophylaxis was 87% effective and 88% of the strains tested were sensitive to sulfadiazine.

Activity W_2 received new trainees during the first week of December. Between December 12 and January 2, 1945, when this class was graduated there were twenty-eight Group A streptococcal infections (types 17 and 3) among the men receiving prophylaxis and fifty-two (types 17, 3, 24 and 44) in the control group. Chemoprophylaxis was 43% effective and 68% of the streptococcal strains tested were sensitive to sulfadiazine.

Activity H_1 had a complement of approximately 800 trainees between November 7 and December 5. These men were barracked in one building. Between November 15 and December 5 there were five Group A streptococcal infections (types 19 and 17) among the men receiving prophylaxis and twenty-six (types 19, 17 and 3) in the control group. Chemoprophylaxis was 79% effective and 91% of the strains tested were sensitive to sulfadiazine.

Activity H_2 received new trainees during the second week of December. Between December 13 and December 22 there were ten Group A strepto-

. . . .

(b) *Chemoprophylaxis administered to men in alternate barracks:* Activity E had a complement of approximately 4400 trainees during November and December. They lived together in twenty barracks. Men in half of these barracks received sulfadiazine one gram daily; the other half served as untreated controls. During this two month period there were five Group A streptococcal infections among the men receiving chemoprophylaxis and fifty-one in the control group. The causative agents were types 44, 30 and 6. Chemoprophylaxis was 90% effective and 100% of the strains tested were sensitive to sulfadiazine.

Activity F had a complement of approximately 4200 trainees during November and December. Living arrangements and sulfadiazine administration were similar to those of Activity E. During the two-month period there were no Group A streptococcal infections among the men receiving sulfadiazine and 34 (types 24, 3 and 1) in the control group. Chemo-

in the control groups to be resistant or susceptible to sulfadiazine. Only the control group was used because chemoprophylaxis tends to eliminate the susceptible strains from the treated group. The percentage of suscept-

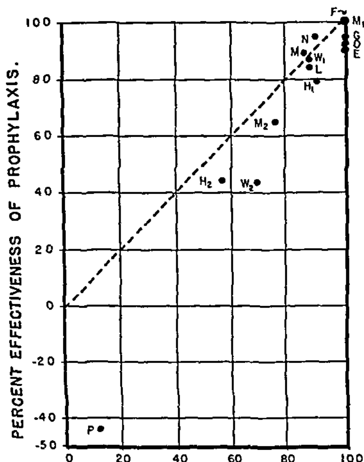


FIG 1 The Relation between Effectiveness of Chemoprophylaxis and Sensitivity of Streptococcal Strains to Sulfadiazine

ible strains prevalent at each station is shown in the final column In most instances, this is approximately the same as the percentage effectiveness of chemoprophylaxis determined by the formula shown in Table 2

outbreak of scarlet fever occurred in December at Activity X, where two recruit regiments were segregated according to the period of training. Regiment X_1 had a complement of approximately 10,000 men who were between the third and tenth weeks of training. Regiment X_2 had a complement of approximately 4,000 men in the first three weeks of training. The outbreak of scarlet fever was limited to Regiment X_1. The first cases were observed during the second week of December. The following week there was a marked rise in the morbidity rate for scarlet fever. Chem-

TABLE 2

Clinical and Bacteriologic Findings during Chemoprophylaxis

Activity	Controls		Treated		Results	Lab Findings		Results
	Group A Infections	Rate %	Group A Infections	Rate %	Percent* Effectiveness	Resistant Strains	Susceptible Strains	Percent Susceptible
M_1	10	1.4%	0	0	100%	0	10	100%
M_2	51	8.9%	17	3.1%	65%	10	31	76%
W_1	39	8.5%	5	1.1%	87%	3	21	88%
W_2	52	9.5%	28	5.4%	43%	11	24	68%
H_1	26	6.2%	5	1.3%	79%	2	20	91%
H_2	14	4.1%	10	2.3%	44%	5	7	58%
E	51	2.3%	5	0.23%	90%	0	19	100%
F	34	1.6%	0	0	100%	0	21	100%
G	37	1.7%	2	0.09%	95%	0	12	100%
L	82	10.3%	13	1.6%	84%	3	23	88%
M	197	8.8%	22	0.9%	89%	4	25	86%
N	307	15.9%	21	0.84%	95%	5	48	90%
O	224	11.2%	17	0.85%	92%	0	15	100%
P	70	3.45%	88	5.00%	−45%	7	1	12%

* Percent effectiveness equals $\frac{\text{(Rate for Controls)} - \text{(Rate for Treated)}}{\text{(Rate for Controls)}} \times 100$

oprophylaxis was administered from December 26, 1944 to January 7, 1945. During this two-week period the scarlet fever morbidity curve climbed abruptly and reached a peak of approximately 1,200 during the middle of January. The causative agent in each instance was type 17 resistant in vitro to 125 mg. % sulfadiazine. Regiment X_2 escaped scarlet fever and no prophylaxis was administered. It was evident that chemoprophylaxis was ineffective.

2. *The Results of Testing in Vitro Resistance of Hemolytic Streptococci to Sulfadiazine.* A large percentage of cultures from each station was typed

CHAPTER XXI

POTENTIAL FACTORS IN THE SPREAD OF STREPTOCOCCUS HEMOLYTICUS ON WHICH INFORMATION WAS LACKING PRIOR TO WORLD WAR II

Military strategists are fully aware of the role that epidemic infections play in the outcome of wars. Prior to the twentieth century these infections were not controllable. Typhoid fever was first prevented in World War I; tetanus, malaria, yellow fever and other diseases were brought under control during World War II. Respiratory tract infections have, however, remained in many instances refractory to preventive medicine measures.

The morbidity rates of World War I emphasized the importance of respiratory tract pathogens. The 1918 pandemic of influenza produced more American casualties than did the German Army. Furthermore, during 1917–18 there were more than 240,000 streptococcal infections in the armed forces; at least 7% of the mean annual armed strength were infected; 56,000 cases of rheumatic fever or acute rheumatism were recorded. In addition, primary streptococcal pneumonia became prevalent in the wake of influenza, isolation techniques failed to control its spread; fulminating empyema and death became a common experience.

Early in World War II epidemics of streptococcal infections were followed by a high incidence of rheumatic fever among Royal Navy men in recruit training (34). British investigators accelerated their research effort on air sanitation and developed techniques for the sterilization of air and the elimination of dust-borne infected particles (35) It was demonstrated that the oiling of floors and blankets produced a striking reduction in the bacterial count of air samples (32, 36). However, it was not shown that this measure reduced streptococcal morbidity rates Dudley (22) had pointed out that at least five environmental conditions facilitated the genesis of streptococcal outbreaks in the training of Naval recruits. These were: (1) high rate of change of population, (2) overcrowding, (3) the introduction of large numbers of susceptible hosts, (4) widespread activity of respiratory tract viruses, (5) the appearance of a type of hemolytic streptococcus with great capacity to infect

Early in 1942 it became apparent that some, if not all, of these conditions prevailed in the Training Centers of the U S. Navy. In anticipation of an epidemic of streptococcal infections a conference was called to make recommendations on pertinent preventive measures This conference of military and civilian authorities was held on April 11, 1942, at the National Aca-

The laboratory test used in this study gives reproducible results. Under carefully controlled conditions the effectiveness of chemoprophylaxis can be evaluated clinically. The relation between these two sets of observations is shown in Figure 1.

In summary, a fair correlation exists between the clinical effectiveness of chemoprophylaxis and the in vitro observations on the susceptibility to sulfonamide of Group A hemolytic streptococci grown in a medium free of sulfonamide antagonists

SUMMARY

Methods used for determining the serologic type of hemolytic streptococci in throat flora were at least 90% accurate.

Methods used for determining the sulfonamide resistance of hemolytic streptococci in throat flora were at least 80% accurate.

There was good agreement between the in vivo and in vitro observations on the sensitivity of Group A hemolytic streptococci to sulfonamides.

B. PERSONNEL (BUREAU OF PERSONNEL)

1. What system should be used in the barrack allocation of new recruits?
2. What exceptions should be made in training schedules for the day following immunizations?
3. What exceptions should be made during an epidemic to the granting of leave after completion of training?
4. What changes should be made in those regulations on the cleaning procedures in barracks which create health hazards?
5. What provision should be made for retaining on a station a draft of *outgoing men among whom streptococcal infections are prevalent?*

C. MEDICAL (BUREAU OF MEDICINE AND SURGERY)

1. What isolation precautions should be taken in Receiving Barracks?
2. What precautions should be taken for decontaminating buildings prior to the entrance of new recruits?
3. What isolation precautions should be taken in dispensaries at Sick Call?
4. What isolation precautions should be taken in dispensary wards?
5. What acute streptococcal infections should be treated within a camp in preference to transfer to a hospital?
6. What isolation precautions should be taken in hospital wards?
7. What precautions should be taken with food handlers?
8. What precautions should be taken in the dispensing of milk?
9. What precautions should be taken in the use of nebulizers for nasal treatments?
10. What precautions should be taken with material used by many men, e g , clinical thermometers, nasal specula, gas masks, etc.?

D. RESEARCH (BUREAU OF MEDICINE AND SURGERY)

1. What roles do dispensaries and hospitals have in the spread of streptococcal infections?
2. What are the sources of contamination within recruit camps?
3. What are the important reservoirs of hemolytic streptococcus in recruit training?
4. What advantages may accrue from dust control?
5. What role do the "steel-wooling" and dry sweeping of barracks floors play in the spread of infections?
6. Does triple or double bunking of men in barracks, dispensaries and hospitals aggravate the spread of contagion?

demy of Sciences in Washington, D. C. There was a wide divergence of opinion on the preventive measures considered. The following recommendations of the conference were approved by the Bureau of Medicine and Surgery of the Navy Department:

1. "The Bureau recommends the abandonment of the present initial period of detention (three weeks) at Naval Training Stations since it serves no useful purpose in the prevention or control of infectious diseases.

2. "It is recommended that various units of 1,200 to 2,000 recruits be instituted for messing and bunking purposes. This group is to be held intact throughout its entire training period. It is the opinion that infectious diseases are spread in connection with messing and bunking and *not* during work or training activities. It is further recommended that each unit as a whole or group be given leave when practicable at approximately the fourth week. This will allow the group to be held intact after return from leave for sufficient time to extend beyond the incubation period of all communicable diseases. It is the opinion that this method would decrease time loss due to certain diseases after the men are sent to sea."

The first of these recommendations was put into effect atmost Training Centers; however, no action was taken on the second. Subsequent events proved that few facts were available to the group of men who were called upon to reach conclusions that would soon determine the health and future of more than three million Naval personnel. The points on which factual knowledge was needed at that time concerned several Bureaus of the Navy. For convenience they are listed as pertaining to Construction, Personnel, Medicine and Research.

A CONSTRUCTION (BUREAU OF YARDS AND DOCKS)

1. What priority should be given to medical buildings in the construction of a new station?

2. What isolation facilities should be provided for the control of communicable diseases at Sick Call and in bed?

3. What facilities should be provided for the handling of men convalescing from streptococcal infections?

4 What provisions should be made for housing the well and the sick in Outgoing Units?

5. What limitations should be made on the size of a camp in Training Centers?

6 What limitations should be made on the size of groups barracked together?

CHAPTER XXII

CONCLUSIONS

This is a study of streptococcal diseases as they occurred in the four war years among more than three million young Americans. It records observations, clinical and bacteriologic, from Naval stations located in every section of the United States. It indicates the spread of hemolytic streptococcus from man to man in barrack, from a barrack to a dispensary, from a dispensary to all barracks of a camp, from the camp to a Naval Hospital, from the hospital to all camps on a station and from a station to many Naval Activities throughout the United States These observations are illustrated in Figures 1, 2, 3, 4, 5 and 6 The study attempts to indicate certain relationships between diverse clinical manifestations and the natural history of hemolytic streptococcus It is essentially a report from "the field." It makes no contribution to the fundamental knowledge of bacterial life or of human disease, nevertheless, it does make facts available which no other period of American history has afforded. Some of these observations are not new. They merely confirm on a large scale what previous epidemiologists have shown in less extensive but perhaps better controlled investigations However, other observations recorded in this study are new in that they had not been made prior to World War II. Many of these facts, mostly old but partly new, may now be marshalled to serve the primary purpose of this integration of U S. Navy experiences, namely, to define more sharply the paths of spread of hemolytic streptococcus and to indicate rational measures for the prevention of air-borne streptococcal epidemics

This study supplied strong confirmation to the findings of Dudley (22) on those factors inherent in military training which are favorable to the genesis of streptococcal epidemics. It supported previous observations on the importance of rheumatic fever in military history (37). It substantiated the experiences of epidemiologists concerned with the spread of the enteric pathogens, namely that basic hygienic measures are essential to the effective application of specific measures for the control of communicable diseases It reemphasized the necessity for medical representation on the highest councils of military strategists, a necessity which has not been fulfilled in any military organization. It again showed clearly that scarlet fever and streptococcal nasopharyngitis without a rash are caused by the same infectious agent and represent a single epidemiologic problem in two types of hosts, those relatively susceptible and those relatively refractory to erythema after absorption of erythrogenic toxin It supplied convincing evi-

7. What temperature and humidity controls should be instituted in class rooms and barracks?

8. What carriers of hemolytic streptococcus are a source of contagion?

9 What provision should be made for sterilizing contaminated gear of men on transfer?

10. What protection can be expected from chemoprophylaxis?

11. What precautions should be instituted should resistant strains of hemolytic streptococcus prevail?

SUMMARY

The prevention of streptococcal outbreaks in future large scale training programs requires factual information on these questions This report attempts to make available only the factual information collected in the United States Navy during World War II. However, it is evident that effective streptococcal control in the future will require the cooperative action of several Bureaus of the Navy Department and representation of Medicine on the highest level of military planning.

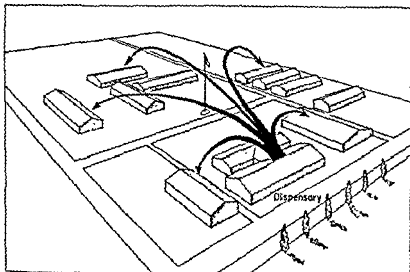


FIG 3 The Spread of Streptococcal Infections from a Dispensary throughout a Camp

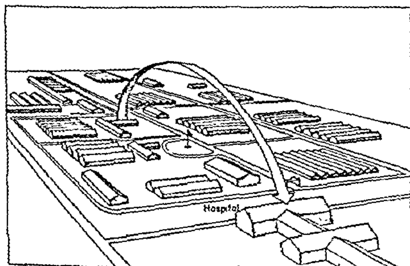


FIG 4 The Spread of Streptococcal Infections to a Naval Hospital

Fig 1 The Spread of Streptococcal Infections in a Barrack

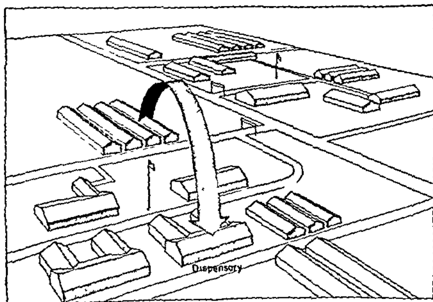


Fig. 2 The Spread of Streptococcal Infections from a Barrack to a Camp Dispensary

FIG 3. The Spread of Streptococcal Infections from a Dispensary throughout a Camp

FIG 4. The Spread of Streptococcal Infections to a Naval Hospital

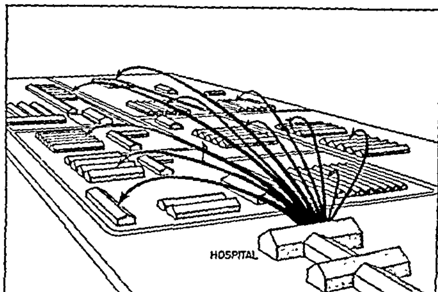


FIG 5 The Spread of Streptococcal Infections from a Naval Hospital to All the Camps on a Station

FIG 6 The Spread of Streptococcal Infections from a Training Center to Many Naval Activities Throughout the United States

dence that streptococcal activity is more extensive and more prolonged in Northern than in Southern States. It confirmed the findings of experimentalists that a microorganism increases its infectivity during an epidemic (38). *It corroborated the opinion that the capacities to cause scarlet fever* and induce rheumatic fever are characteristics of Group A hemolytic streptococcal strains. It supported the observation (39) that the capacity of these strains to induce rheumatic fever may be associated with their capacity to produce a strong erythrogenic toxin. It showed that a few serologic types may cause the majority of infections over a period of years and that the introduction of a new organism on a station may result in a streptococcal epidemic. This is illustrated in Figure 7.

The availability of new and more refined methods for differentiating hemolytic streptococcus afforded a more accurate tracing of the spread of streptococcus than was possible prior to World War II. With these methods it was possible to demonstrate that probably a single strain of hemolytic streptococcus produced a severe epidemic and that probably a single host introduced a strain of hemolytic streptococcus which over a period of months infected large numbers of men. Within a Naval training station it was shown that the camp dispensary and the hospital were the most important focal points for the dissemination of contagion, first throughout a camp and then to all camps of the station. For the first time it was possible to demonstrate that the movement of Navy trainees spread hemolytic *streptococcus to many areas of the United States. In at least* one instance one strain of hemolytic streptococcus was found to have the capacity to produce a severe, air-borne epidemic in a semi-tropical environment. This microorganism was shown to have an unusual capacity to survive when exposed to high experimental temperatures. Furthermore, it was shown that some factors in the environment of the Rocky Mountains of Northern Idaho appeared to maintain the infectivity of hemolytic streptococcus throughout all months of the year and to favor a seasonal rise in the epidemic curve during mid-summer when streptococcal activity was minimal at other points in the United States. It was observed that when persons carrying these strains arrived at other points they gave rise to streptococcal outbreaks only during the winter months when upper respiratory tract infections were prevalent at the points of their arrival. Irrespective of the geographical location of these points, these strains manifested the same *capacity to cause scarlet fever and induce rheumatic fever that* they had shown in Northern Idaho.

The facts collected on the relation of mass chemoprophylaxis to the epidemiology of hemolytic streptococcus were also new. Continuous mass chemoprophylaxis had not been tested as a preventive medicine measure prior to World War II. Its limitations and effectiveness were first explored

by the U. S Navy in 1943–45. The oral administration of one gram of sulfadiazine daily proved 85% effective in reducing the morbidity rates for respiratory tract infections caused by bacterial agents sensitive to sulfadiazine in vitro. This marked reduction in streptococcal infections was followed by a similar reduction in rheumatic fever. Hypersensitive reactions of the host occurred in only 0 5%. The limiting factor in mass chemoprophylaxis proved to be the presence and spread of Group A sulfonamide resistant strains provided these strains were highly communicable and pathogenic for man. Chemoprophylaxis screened the sulfon-

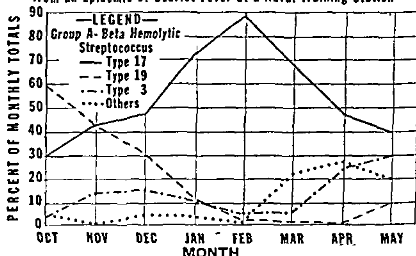


Fig 7 Changes in the Throat Flora during a Streptococcal Epidemic

amide sensitive strains but was ineffective in limiting the spread of the highly communicable, sulfonamide resistant organisms There was evidence that neither chemoprophylaxis nor chemotherapy induced or modified [illegible] hemolytic streptococcus. These findings were in [illegible] hemoprophy- [illegible] were introduced into environments conducive to their rapid passage Furthermore, one of these strains had the capacity to cause a large number of infections in a warm, sunny climate under conditions considered unfavorable to the spread of hemolytic streptococcus The replacement of sulfonamide sensitive hemolytic streptococci at many Naval Activities by sulfonamide resistant strains lowered to a marked degree the practical value of mass

chemoprophylaxis This experience reemphasized the fact that basic sanitary principles are essential and that mass chemoprophylaxis can be used effectively only as an adjunct to those measures which will limit the rapid transmission of hemolytic streptococcus in overcrowded Training Centers where a rapid turnover of recruits occurs However, it seems unlikely that these findings on the use of mass chemoprophylaxis "in the herd," apply to the administration of chemoprophylaxis to small, isolated groups of rheumatic subjects

The cumulative evidence collected at many locations and under varying conditions makes possible an appraisal of the relative importance of the "potential factors in the spread of *Streptococcus hemolyticus*" outlined in Chapter XXI:

1. It is evident that the initial planning of a Naval Training Center may determine whether the Center becomes heavily seeded with hemolytic streptococcus. From these studies, it seems clear that the more northerly the Center is located, the greater is the expected risk of streptococcal epidemics That both the hospital and dispensary facilities must be adequate for the care of patients with communicable diseases when a new station is opened appears obvious The hospital must include wards where patients with streptococcal infections can be handled with the same isolation techniques which are available in civilian institutions The dispensary must be provided with a waiting room large enough to seat and separate men appearing at Sick Call Moreover, there must be one barrack in each camp of a Training Center where convalescent patients can be housed until recovery from streptococcal infections is complete These requirements for recruit camps must also be met in the Outgoing Unit which transfers men to many Naval Activities There is no evidence in this study that the size of a recruit camp influences streptococcal morbidity rates However, it appears that the incidence of these infections may be determined in part by the number of men sleeping together There is good reason to believe that the dormitory spread of streptococcal infections can be modified by compartmentation of barracks and by limiting the number of men sleeping together to groups of eight This, however, will not lower the incidence of infections contracted at Sick Call or at other danger points in a camp

2 It is evident that the weekly seeding of new recruits among men in the early and convalescent stages of upper respiratory tract infections is conducive to the initiation and prolongation of an epidemic process Men arriving from civilian life must be barracked together in a manner which will give them the maximum isolation from older recruits on the Training Center especially at Sick Call Since most streptococcal infections are acquired from contagion existing on a Center and are not introduced by the

new arrivals, a preliminary three weeks' quarantine period is not effective. There is need, however, for light duty during an initial three weeks' period in which recruits receive multiple immunizations and make adaptation to a new environment. It must be recognized that the granting of a two weeks' leave to all recruits on the completion of training during periods when streptococcal morbidity rates are high spreads these infections throughout the civilian population. If the barrack spread of streptococcal infections is to be modified, the customary emphasis placed on polishing floors must be superseded by emphasis on techniques for the removal of bacterial contamination. This applies not only to the barrack but also to the dispensary and hospital. In time of war, the establishment of an overflow facility in an appropriate environment in the South is essential for the quarantining of Outgoing Units which manifest a high incidence of streptococcal infections. Otherwise, the seeding of these men into many Naval Training Activities can be expected to initiate numerous streptococcal outbreaks

3 It is evident that the newly arrived recruit may become infected in the receiving barrack prior to his assignment to a recruit camp. Protection against such infections requires periodic decontamination of the receiving barrack. Likewise protection against infection early in recruit training requires decontamination of each barrack after the graduation of a company and prior to the admission of newly arrived recruits At Sick Call, close association between recruits with minor complaints and recruits with streptococcal diseases must be avoided. Attainment of this objective can be facilitated by limiting men who appear at a dispensary for a Sick Call visit to those in the same period of training. Since hours for these visits are held only two or three times daily, there is ample opportunity to decontaminate the dispensary between visiting hours Most of the patients who are admitted to dispensary wards have communicable diseases. It is therefore essential that these wards afford adequate isolation facilities or that each camp have "Bethesda type" wards where the sick can be treated. For many reasons the latter is preferable. With the addition to each camp of a building with adequate isolation facilities for the patient in bed, two advantages may be expected. first, patients with streptococcal infections, irrespective of rash, can be treated within the camp and escape cross-infections acquired in the hospital wards from men of other camps, second, patients having streptococcal infections without a rash can be handled with the same isolation techniques which are applied to scarlet fever patients Under these circumstances, it will be possible to avoid the customary mistake of returning a man to duty on the third day of a strep-

infecting these men with hemolytic streptococcus This requires proper sterilization of clinical thermometers, nasal specula and perhaps the elimination of routine treatments with nasal sprays In addition to the danger of air-borne streptococcal infections there is always the possibility of a food-borne outbreak induced by contamination through the air. Protection against this requires that milk be served only in closed containers and that food handlers be examined daily to screen not only those with acute respiratory diseases but especially men with subacute or chronic sinus infections When recruits are transferred from a camp to the Naval Hospital it is essential that they be isolated from men of other camps who are in the acute or subacute stages of streptococcal infections.

4 Attention has been called to a number of observations which merit *further analysis and investigation. That the application of contaminated* nasal sprays under strong, positive pressure may cause mass infection with hemolytic streptococcus should be subjected to experimental proof if this is necessary to eliminate doubt about this hazard The possibility that dust reservoirs on linoleum covered floors are less contaminated than reservoirs of dust on floors covered with asphalt tile should be further investigated The concentration of calcium hypochlorite solutions essential to decontaminate floor dust should be determined. Further studies should be made to determine whether the dry heat of radiators sterilizes dust. It is of practical as well as academic importance to determine what factors in the northern regions of the Rocky Mountains increase streptococcal activity. Explanation of the fact that dental personnel escaped scarlet fever may supply enlightening information on the mode of spread of hemolytic streptococcus and on control measures

Certainly, it is essential that knowledge of the epidemiology of hemolytic streptococcus be increased It has been shown that infections contracted in camp dispensaries and Naval Hospital wards play an important role in the epidemic spread of hemolytic streptococcus at Training Centers The Navy's hospital problems in the control of cross infections are similar to those in civilian institutions These problems have been clearly presented by the Committee on Preventive Medicine of the Medical Research Council (41) Nevertheless, more precise information on the mode of spread of hemolytic streptococcus within medical facilities is needed There is also need for more information on the sources of contamination in these facilities It is important that carefully controlled studies be made to determine the effectiveness of measures to protect the recruit from both inanimate and animate reservoirs of hemolytic streptococcus Within the barrack, the effect of temperature and humidity on the incidence of streptococcal infections also requires carefully controlled studies Exact information is urgently needed on the factors which permit certain carriers of hemolytic

streptococcus to spread contagion while other carriers remain harmless. Techniques must be developed which will permit rapid sterilization without injury to bedding and clothing. Further investigations are needed to determine whether chemoprophylaxis can be used effectively when resistant streptococcal strains are present and what precautions should be taken under these conditions. The need for fundamental research on the factor of communicability present in certain streptococcal strains transcends in importance all other requirements.

In conclusion, it is clear that under the conditions of training which obtained at large Naval Activities during World War II, certain strains of hemolytic streptococcus acquired a high degree of pathogenicity and capacity to spread. This resulted in at least a million cases of streptococcal respiratory tract diseases, over fifty thousand cases of scarlet fever and over forty thousand cases of rheumatic fever, rheumatic heart disease and acute polyarthritis. In contrast to these extremely high scarlet fever morbidity rates within Naval Training Centers, the annual rates per 1,000 of civilian population were only 1.04 in 1943, 1.42 in 1944 and 1.25 in 1945. In 1943 there were 114,316 cases of scarlet fever in forty-one states; in 1944, there were 163,119 cases in forty-two states; in 1945 there were 146,761 cases in forty-four states.[1] Many of the circumstances conducive to the near-ubiquitous, streptococcal spread in recruit training were inherent in the rapid expansion program of World War II, which far outstripped the availability of physical facilities. These circumstances suggest their own corrective measures as do those stemming from the critical shortage of medical personnel Both of these situations militated against maintaining recognized control measures of sanitation, segregation and isolation. The experience at Northern stations in general, and at Farragut, Idaho, in particular, makes consideration of geographical location mandatory in any large scale training program, especially of a type involving young Naval recruits.

Although zealous prosecution of control measures can be expected to reduce streptococcal morbidity rates, these infections will continue to occur and to be costly in both man power and dollars until more intimate knowledge of the physiology of the streptococcal cell is attained The staggering loss in man days to streptococcal disease during World War II plus the military exigency served to highlight problems in control and prevention of respiratory tract infections which are recognized to be cyclic among civilian populations. Advances in technique have made possible the identification [illegible]

[1] Data supplied by the U S Public Health Service.

spread and to cause disease, are not available. The mechanism of bacterial resistance to chemostatic agents also is unknown It remains to explore those biochemical processes of the microorganism which condition pathogenicity, epidemicity and chemoresistance and those of the host which modify susceptibility and resistance to infection Elucidation of these mechanisms will be followed by the development of more effective methods for the control and prevention of streptococcal respiratory tract infections and their sequelae

In brief, this report supplies quantitative data on contamination by hemolytic streptococcus. It indicates that certain strains within types of the bacterium have qualities which make them highly communicable. It does not undertake to deal with the all-important problem which still awaits solution: The definition of the qualitative changes associated with the bacterium's development of communicability. The solution of this problem must come through the collecting of facts in the laboratory by biochemists and biologists who comprehend the significance of the factor of communicability in respiratory tract pathogens. This problem is as difficult as it is challenging On the favorable side are the rapidity with which bacteria multiply, the ease with which they are handled, the grace with which they develop temporary adaptive changes and permanent hereditary mutations, and their susceptibility to the therapeutic agents now available On the unfavorable side is the ever present tyranny of one's ignorance of any small experimental animal which is highly susceptible to infection by Group A *Streptococcus hemolyticus* The key problem is the elucidation of the mechanism of communicability; its solution will probably be the most rewarding in the epidemiology of hemolytic streptococcus. The solution can come from man alone and perhaps in man alone.

GLOSSARY

TERMINOLOGY USED IN U. S. NAVY REPORTS

"Incidence" is the sum of EPTE, A, ACD, and AD.

"—" .	Remaining. Patients remaining on the sick list from the preceding year.
EPTE	Condition considered to have existed prior to entry into the service.
A . .	New admissions to the sick list.
ACD ...	Admitted for a contributory disability, such as a complication or sequela of prior diagnosis.
AD .	Additional diagnosis, not causally related to the prior diagnosis.
RA . .	Readmission to sick list after a period in duty status, for further treatment of the same illness
D	Duty. Returned to duty status
C	Changed. Diagnosis changed by reason of complication, sequela, intercurrent or concurrent diagnosis, error, etc.
DD	Died.
IS ..	Invalided from Service. Discharged from the service because of physical disability.
R	Ran. Deserted while on the Sick List
Con	Continued. Patients continued on the sick list to the following year.

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No attempt has been made to review the literature on the epidemiology of hemolytic streptococcus. References have been made only to certain studies which pertained to a point under discussion. Other studies pertinent to war time streptococcal problems of the military services are listed below.

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